Let them eat insects: evaluating the potential of manure-raised housefly larvae (*Musca domestica)* as a feed ingredient in the diet of rainbow trout *(Oncorhynchus mykiss).*

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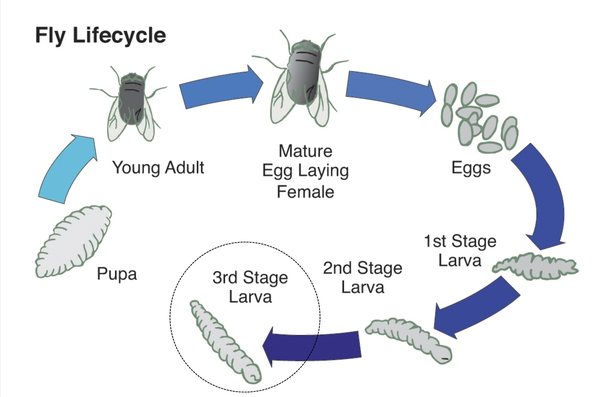
Introduction

Historically, fishmeal has been an excellent, although unsustainable, source of protein for farm- and hatchery-raised fish. To reduce feed costs and improve the sustainability of aquaculture and hatchery operations, alternative sources of high-quality protein must be developed. Housefly larva meal (LM) is a particularly promising alternative to conventional fish feed ingredients: easy to produce, high in protein and fat, and possessing a favorable amino acid profile. Our project aims at exploiting a plentiful local resource, dairy cow manure, to raise insect larvae as a source of protein for fish.

Rearing and Processing of Larvae



Housefly larvae (*Musca domestica*) were raised on organic dairy cow manure using methods previously published by the Selvaraj lab.

Diet Design

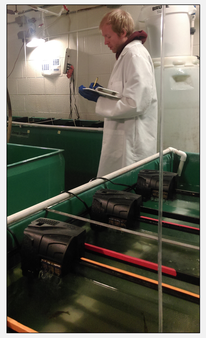
Ingredients	Control Diet	5% Larva eal	30% Larva Meal
Fish meal	10	10	10
Larva meal	**0**	**5**	**30**
Soy protein concentrate	20.7	**15.8**	**0**
Corn gluten meal	20.7	20.7	**12.29**
Wheat gluten	5	5	5
Wheat flour	25.4	26.1	29.7
Fish oil	11	11	11
Soybean Oil	5.8	**4.9**	**0.5**
Mineral/Vitamin Mix	1.5	1.5	1.5
***Formulated using WinFeed 2.8 software**			

Diets were designed following the standard developed by Lee and Hardy (2015), which is meant to be representative of a modern commercial diet for Rainbow trout.

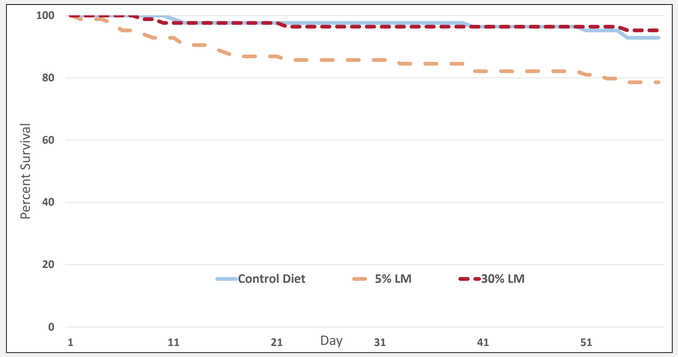
	Larva Meal[a]	Soy Protein Concentrate[b]	Fishmeal[b]
Dry Matter (%)	91.5	94.3	93.7
Crude Protein (%)	56.39	67.4	67.8
Fat (%)	16.78	2.1	9.0
Digestible Energy (Mcal/lb)	1.66	2.23	2.27
Calcium (%)	0.68	0.4	5.4
Phosphorus (%)	1.08	0.8	1.5
[a]This study: analysis performed by Brookside Labs (New Bremen, OH), [b](Barrows et. al 2015)			

Feeding Trial

	Week							
	1	2	3	4	5	6	7	8
Group 1	Standard diet							
Group 2	5% LM diet							
Group 3	30% LM diet							
Group 4	Standard diet						5% LM diet	
Group 5	Standard diet						30% LM diet	
n	6 aquaria per group, 14 fish per aquaria, 84 fish per group							

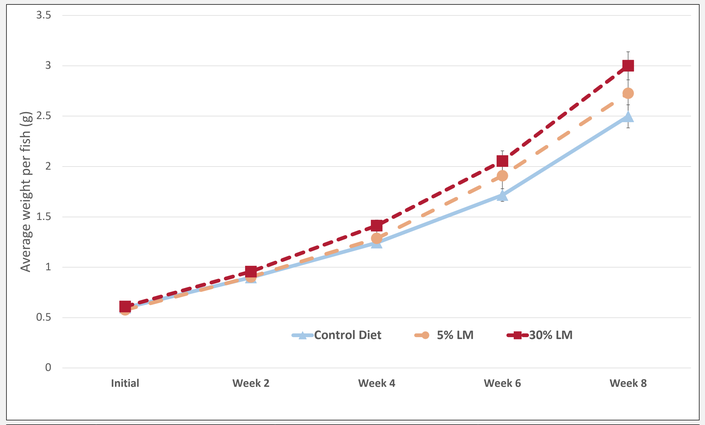


Survival



High mortality was observed in the 5% LM diet (~20% after 8 weeks). Mortalities were examined but no clear cause was identified. This is a statistically significant difference (p<.001, Kaplan-Meyer).

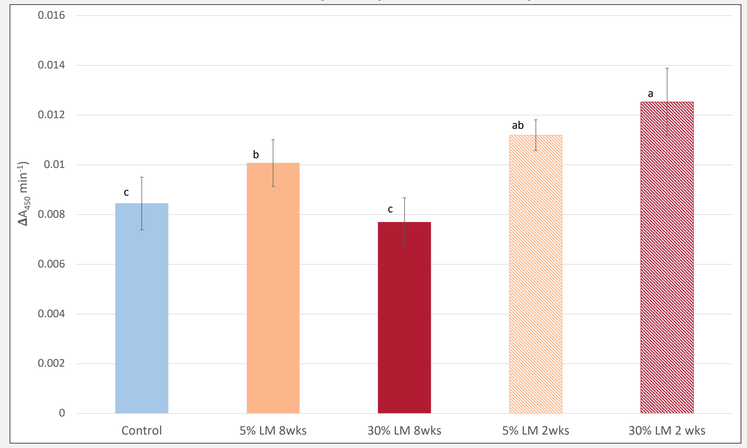
Growth



Diet Group	Feed Intake per tank (g)	Total Weight Gain per tank (g)	Feed Conversion Ratio (FCR)
Control	36.12	23.28	**1.55**
5% LM	36.12	21.32	**1.69**
30% LM	36.12	31.32	**1.15**

A significant difference in both growth and FCR (p <.01) was observed between the 30% LM diet and the control group.

Serum Lysozyme Activity



Serum lysozyme activity was significantly higher in the groups that had recently switched to an LM diet (either 5% or 30%). This effect appears to be transient however, as it was not detectable in the groups that had been eating LM diets for 8 weeks.

Conclusions

- Even with with minimal processing, housefly LM compares favorably to leading modern fishmeal substitutes as an aquafeed ingredient.
- Housefly LM may have immune stimulatory properties which could increase its value as an ingredient in functional feeds.
- Housefly larvae can be produced at low cost by utilizing existing waste streams and the resulting LM is suitable as a feed ingredient for Rainbow trout. This may one day improve the profitability and sustainability of dairy and aquaculture/hatchery operations, mitigate environmental impacts, and reduce reliance on fishmeal.

Future Directions

- Conduct follow-up experiments using LM to directly replace fishmeal
- Work with local farmers to develop ways to upscale LM production
- Investigate immune-stimulatory potential of LM with a focus on how the diet of the larvae might impact these properties

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Literature Cited

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