A BIO-ECONOMIC MODEL FOR ESTIMATING **ECONOMIC VALUES** OF IMPORTANT TRAITS IN BSF

Roos Zaalberg • QGG, Aarhus University, Denmark • EAAP 2024 • September 3rd

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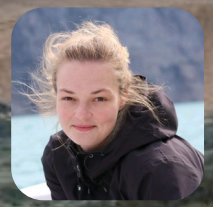


Natasja
Krog Noer

Miljø- og Fødevareministeriet

gudp

AARHUS UNIVERSITY

QGG

ENORM


Black Soldier Flies

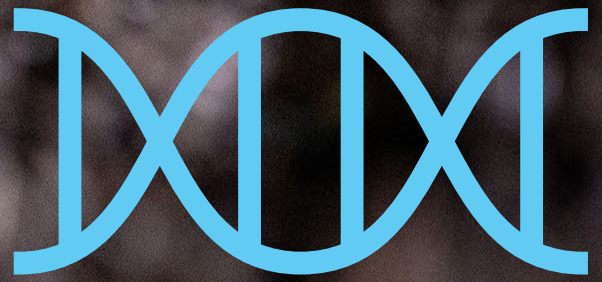
Room for improvement

Aim of this study:

Determine the economic value
for important production traits in BSF
to optimize selective breeding.

Why selective breeding?

Determine the economic value
for important production traits in BSF
to optimize selective breeding.



Why selective breeding?

Selective breeding:

Improving an animal's characteristics

by selecting the best individuals to be parents

to the next generation.

Why selective breeding?

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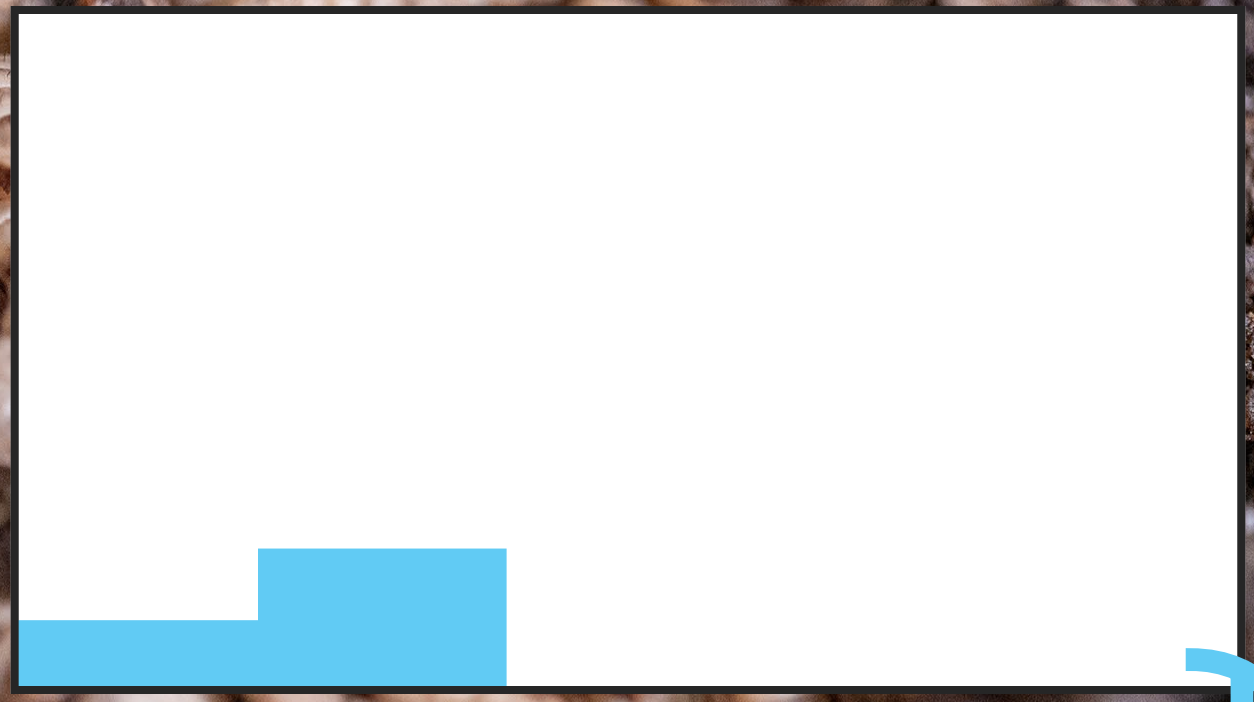
Why selective breeding?



Why selective breeding?

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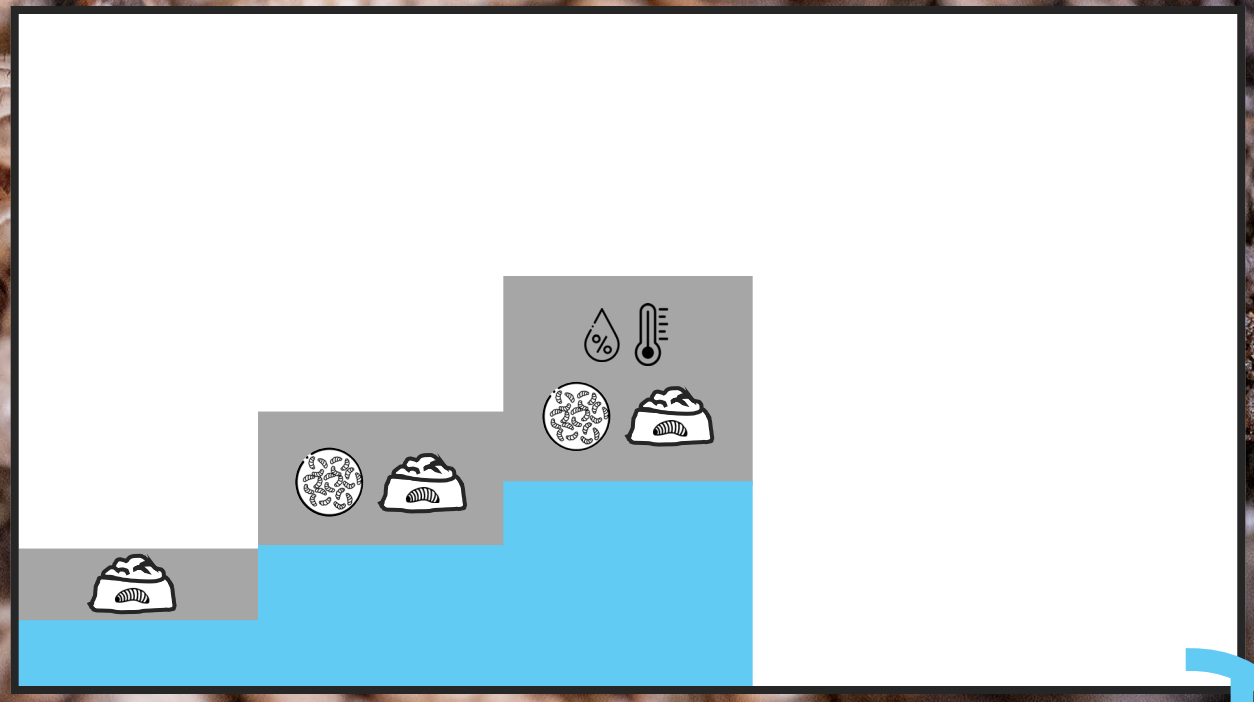
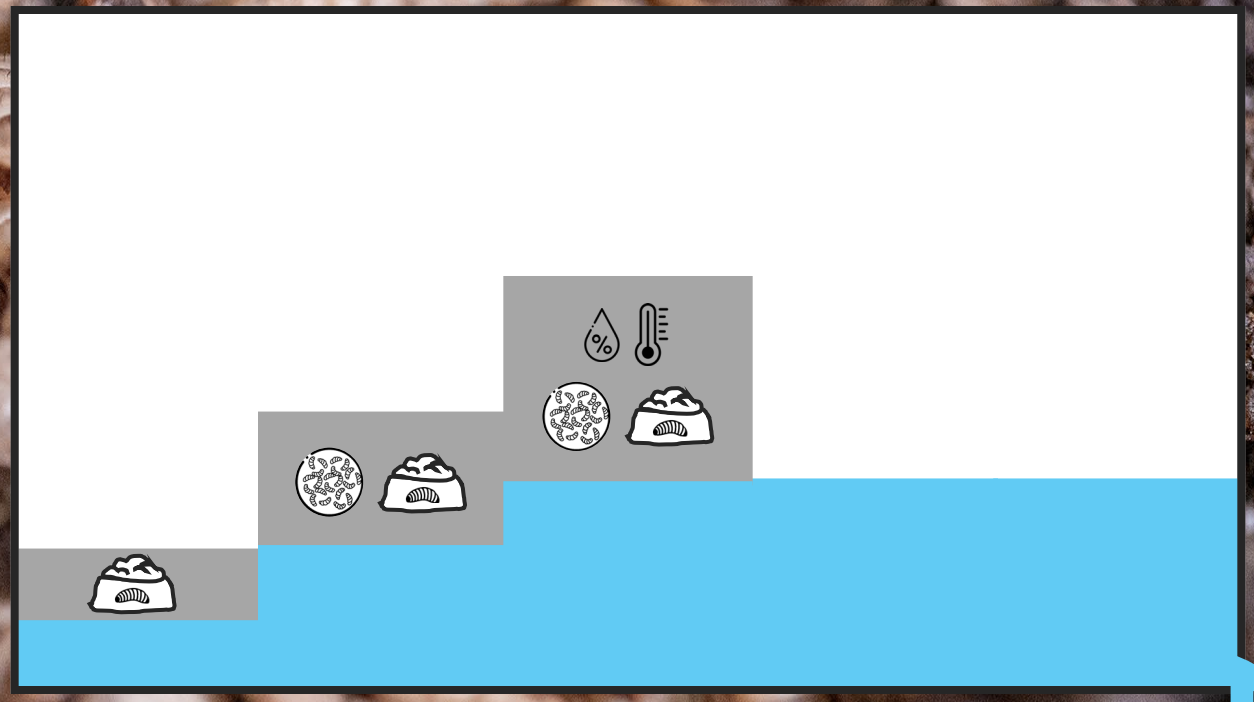
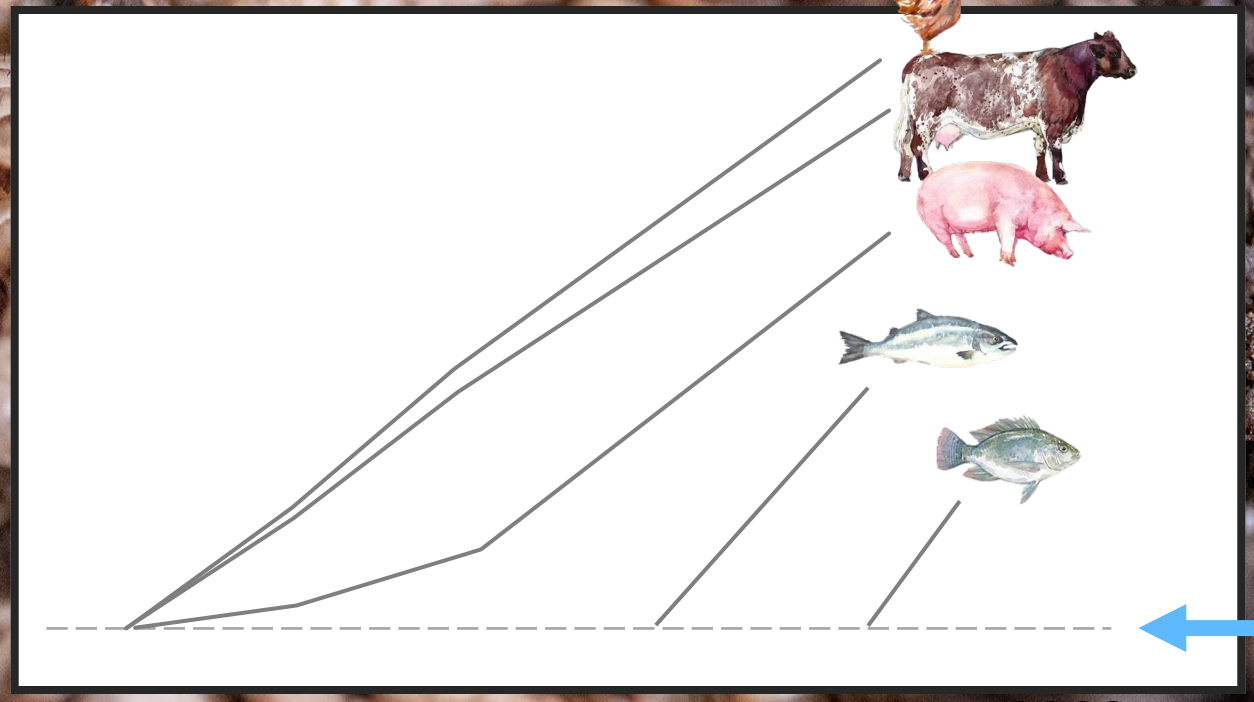


Why selective breeding?



× improvements

= permanent!



INSECTS

great potential!


insect
breeding

insect breeding

past

Phenotypic selection

Single trait selection

Main focus on growth

Challenges:

- Risk of inbreeding
- Multi-trait selection difficult

insect breeding

past

Phenotypic selection

Single trait selection

Main focus on growth

Challenges:

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future

Multi-trait selection

Use family records

Challenges:

- Large-scale phenotyping
- Keeping track of pedigree

insect breeding

Our aim:

Find out which traits to select for

= the breeding objective

past

Phenotypic selection

Single trait selection

Main focus on growth

Challenges:

- Risk of inbreeding
- Multi-trait selection difficult

now

future

Multi-trait selection

Use family records

Challenges:

- Large-scale phenotyping
- Keeping track of pedigree

insect breeding

Our aim:

Find out which traits to select for

= the breeding objective

past | now | future

Phenotypic selection

Single trait selection

Main focus on growth

Challenges:

- Risk of inbreeding
- Multitrait selection difficult

Multitrait selection

Use family records

Challenges:

- Large-scale phenotyping
- Keeping track of pedigree


“Breeding objective”

In which direction do we want to improve the BSF population?

fertility

composition

growth

health

development

survival

How should we prioritize these traits?

fertility

health

competition

development

growth

survival

Aim of this study:

Determine the **economic value**

for important production traits in BSF

to optimize selective breeding.

Materials & Methods

Economic values in a breeding objective

Economic values in a breeding objective

protein% + fat% + survival + fertility + ...

Economic values in a breeding objective

EV_1 * protein% + EV_2 * fat% + EV_3 * survival + EV_4 * fertility + …

Economic values in a breeding objective

EV_1 * protein% + EV_2 * fat% + EV_3 * survival + EV_4 * fertility + …

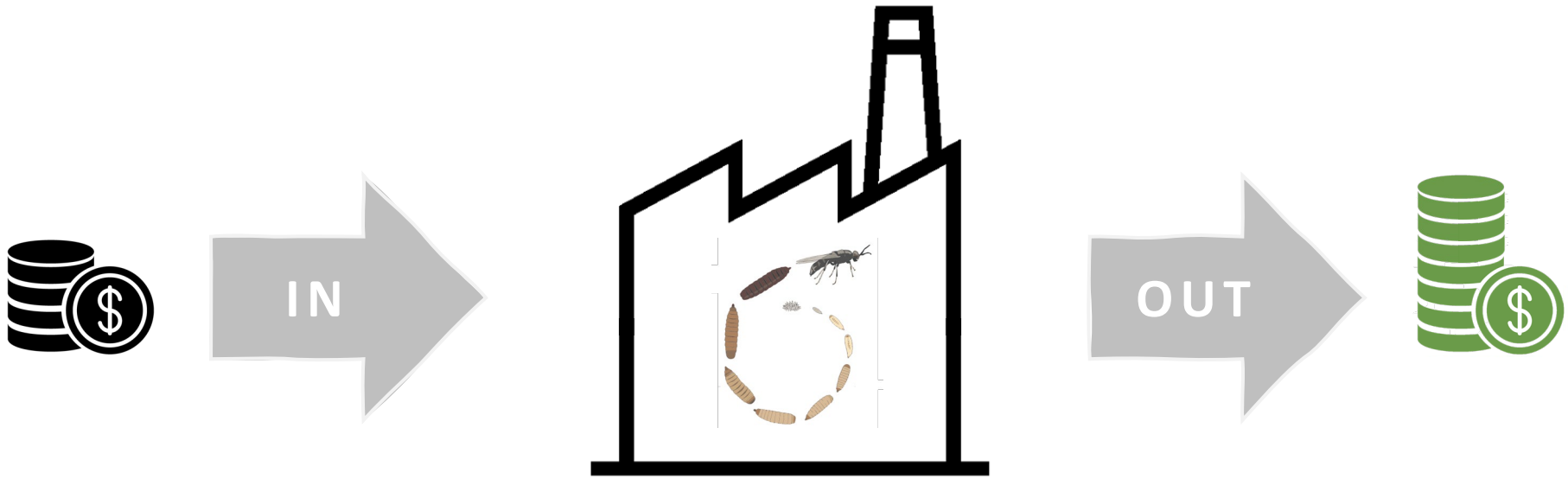
How much does our **profit increase** when we **improve a single trait**?

Economic value of a trait

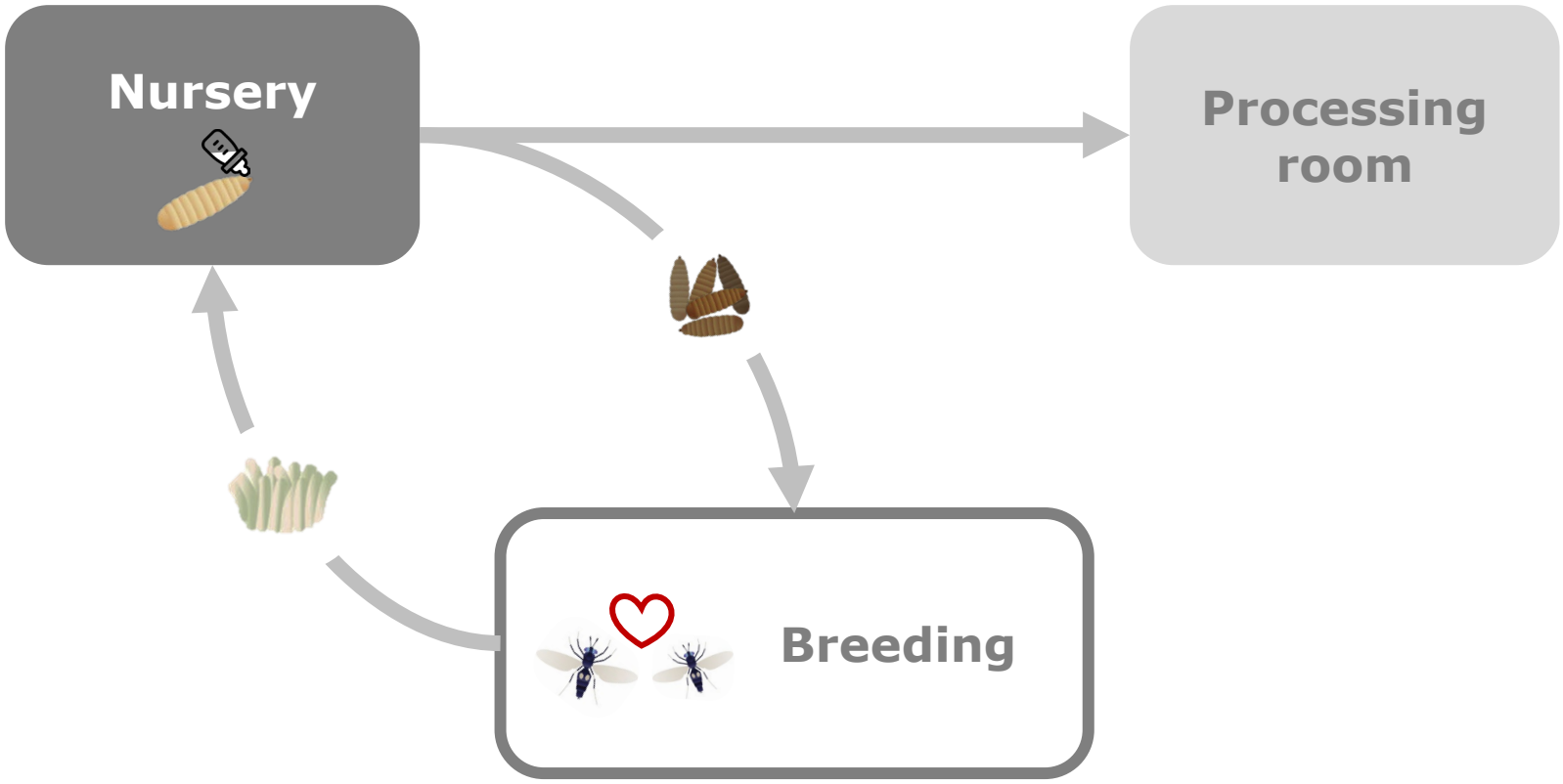
Bio-economic model

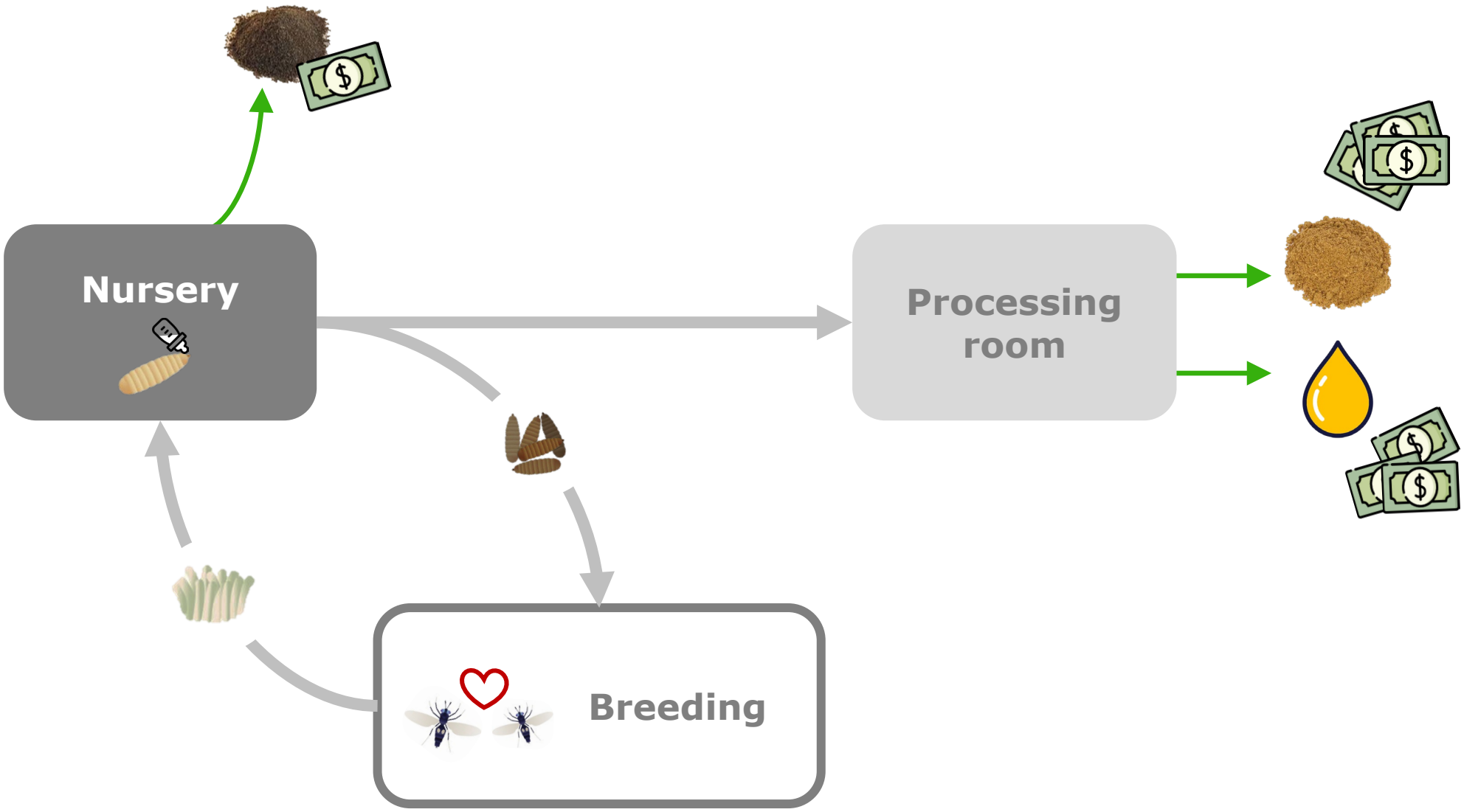
How much does our **profit increase** when we **improve a single trait**?

Economic value of a trait


IN
OUT


IN
OUT


Nursery
Processing room
Breeding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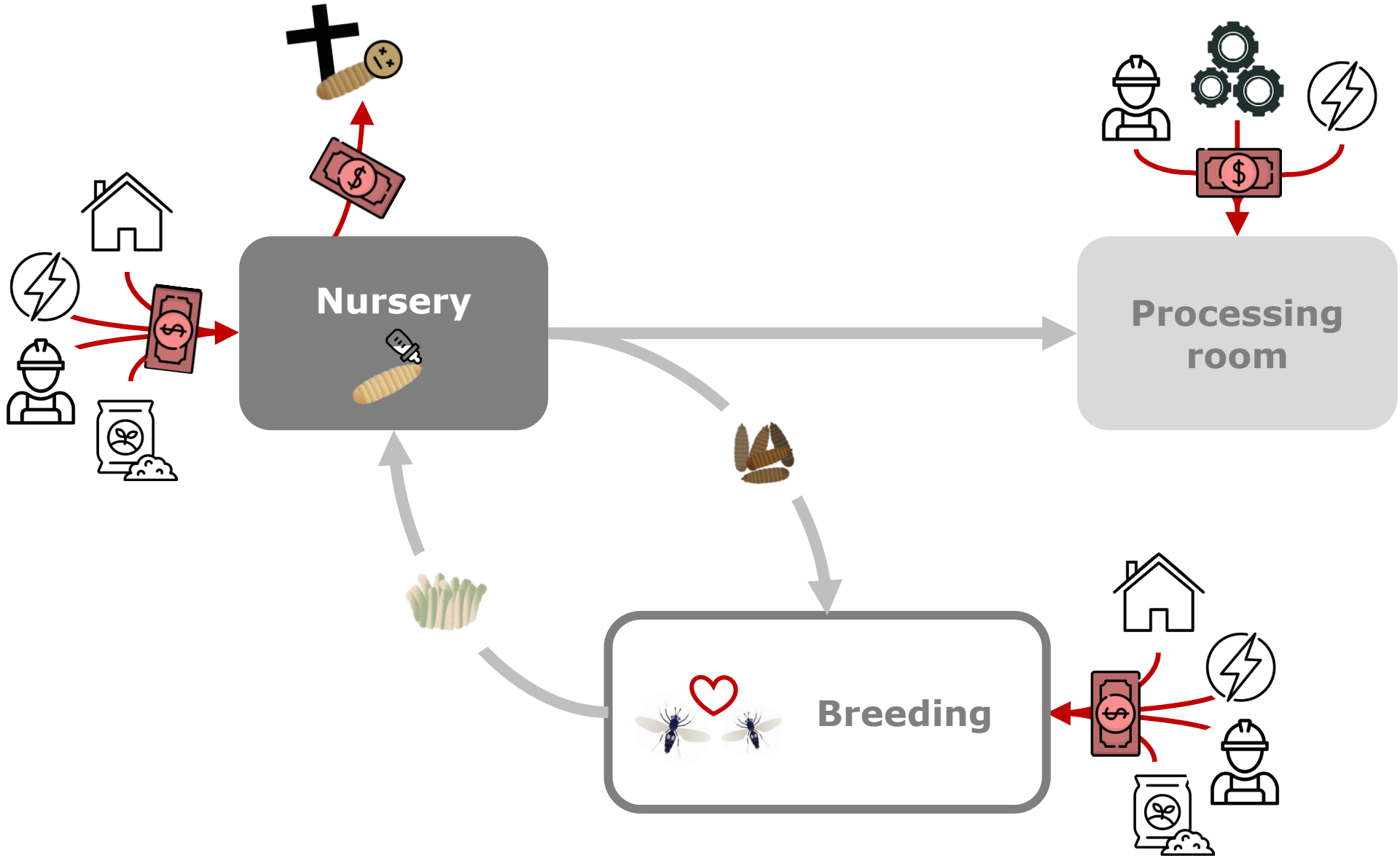
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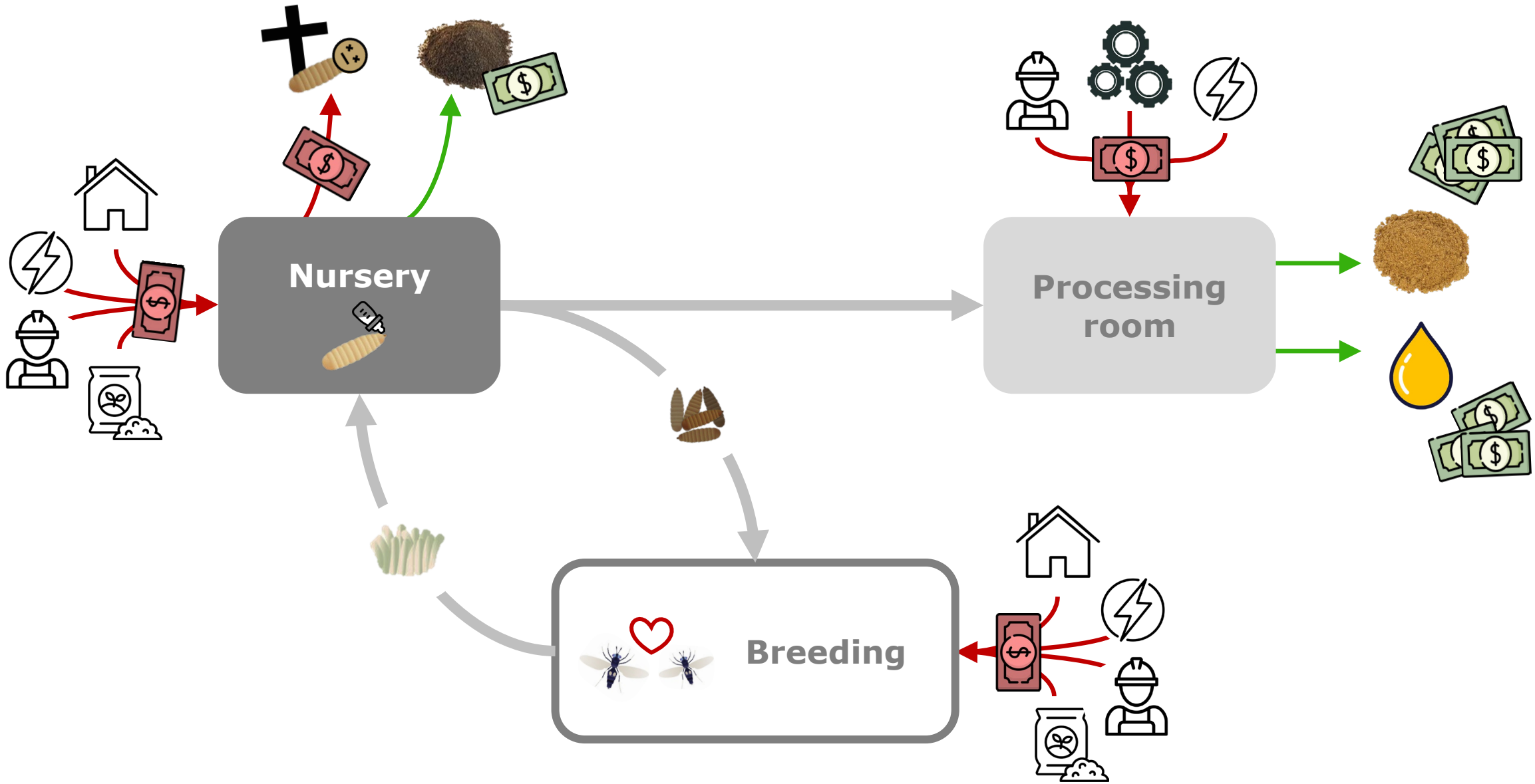
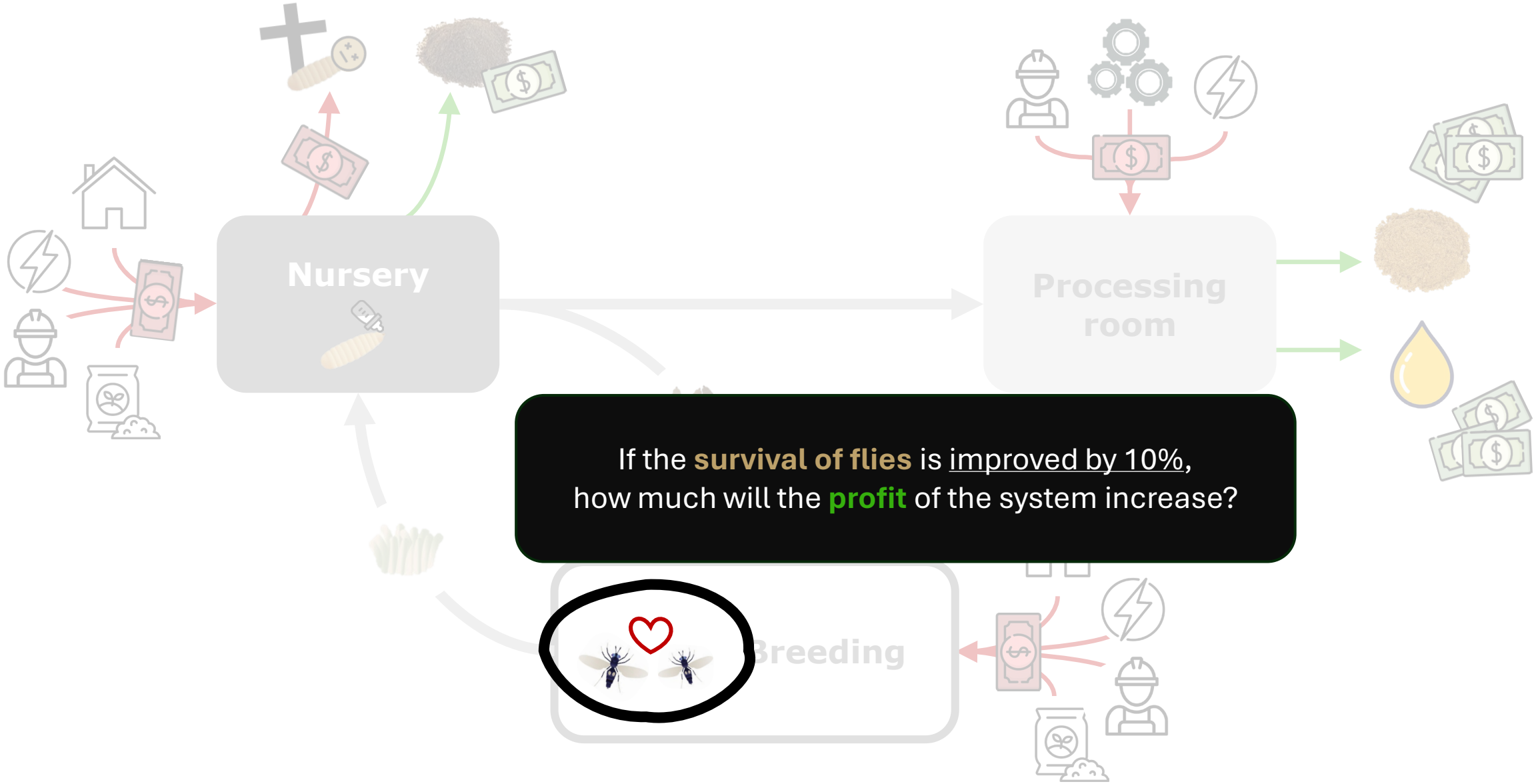
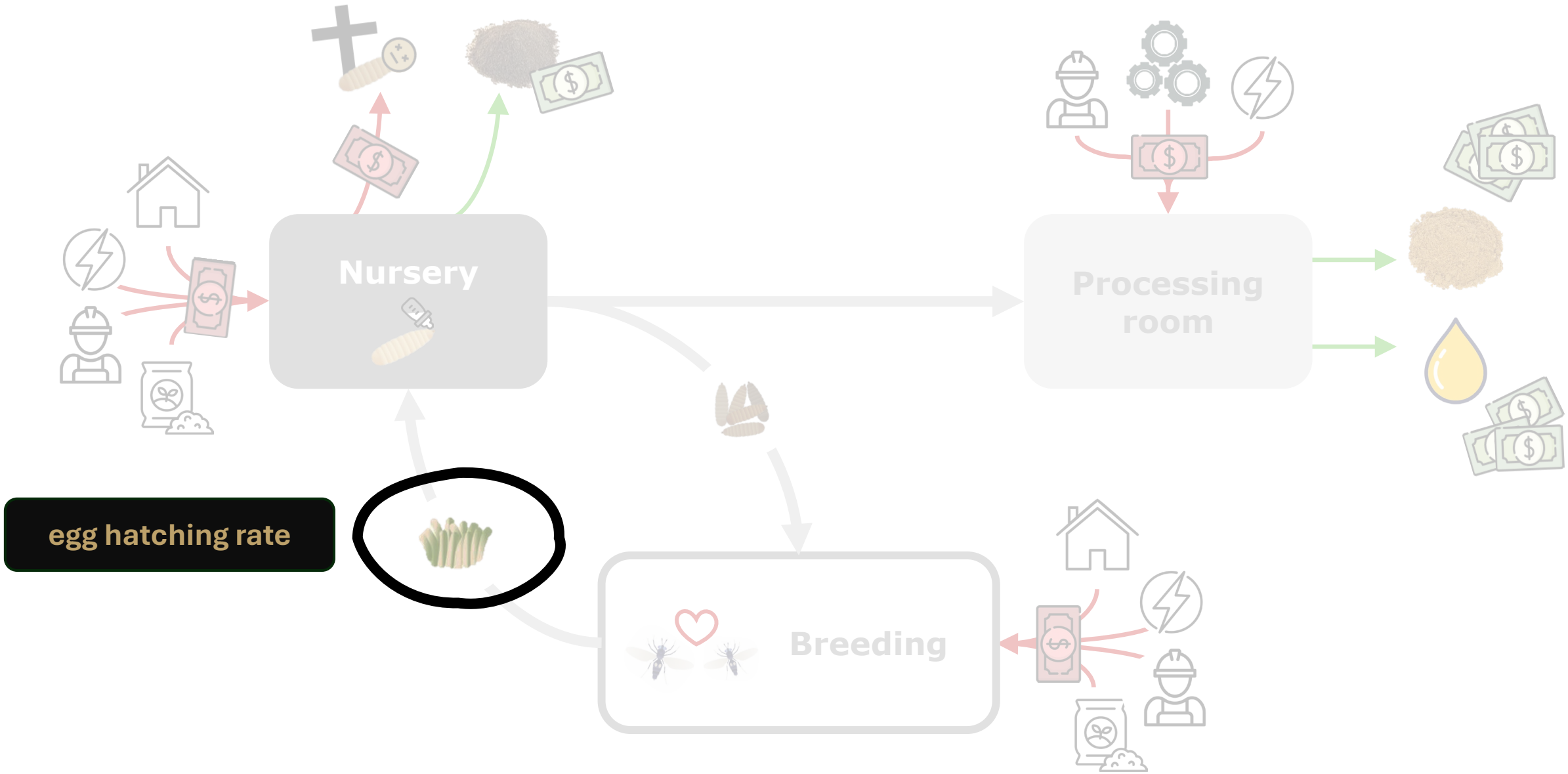
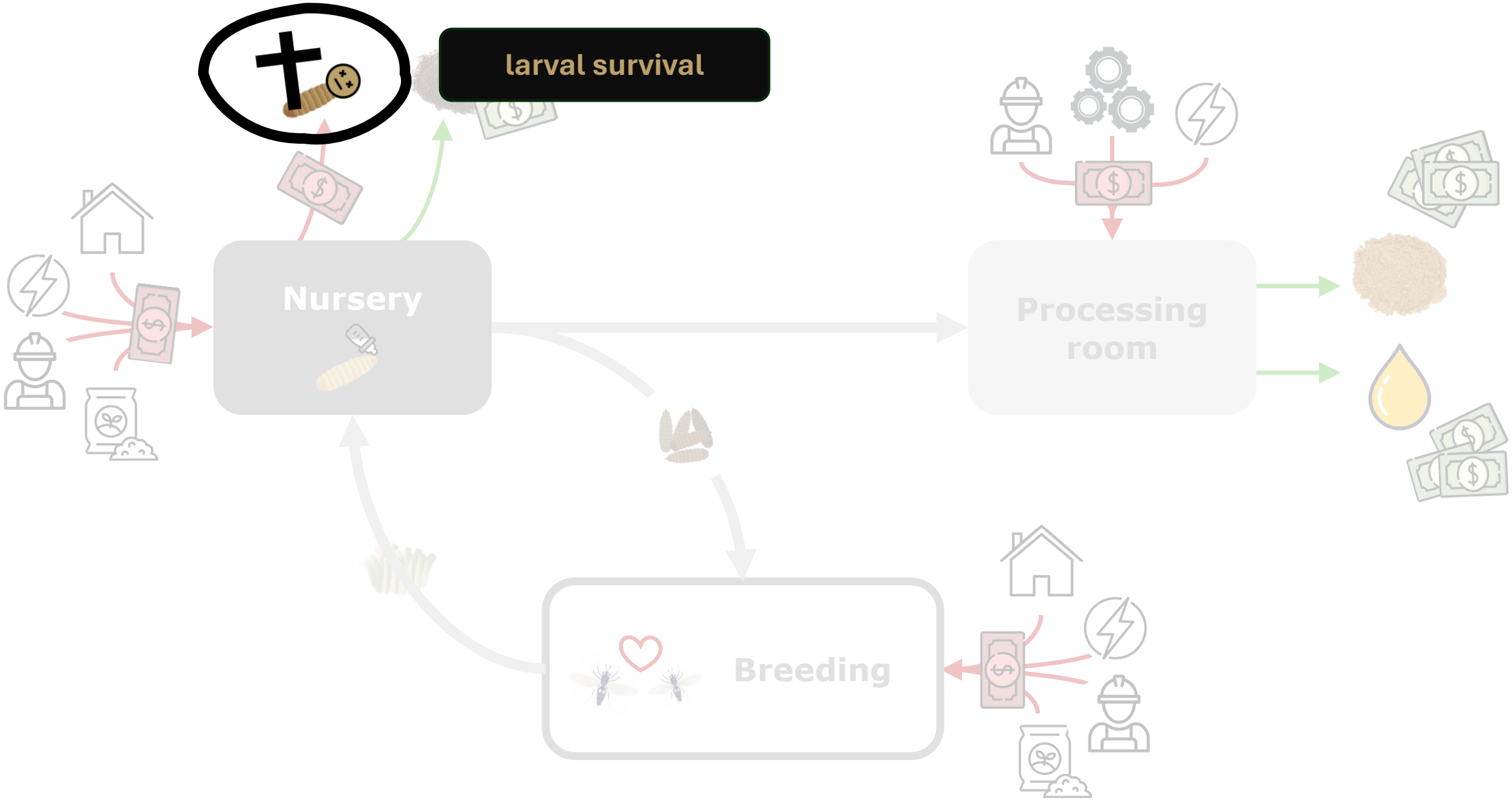
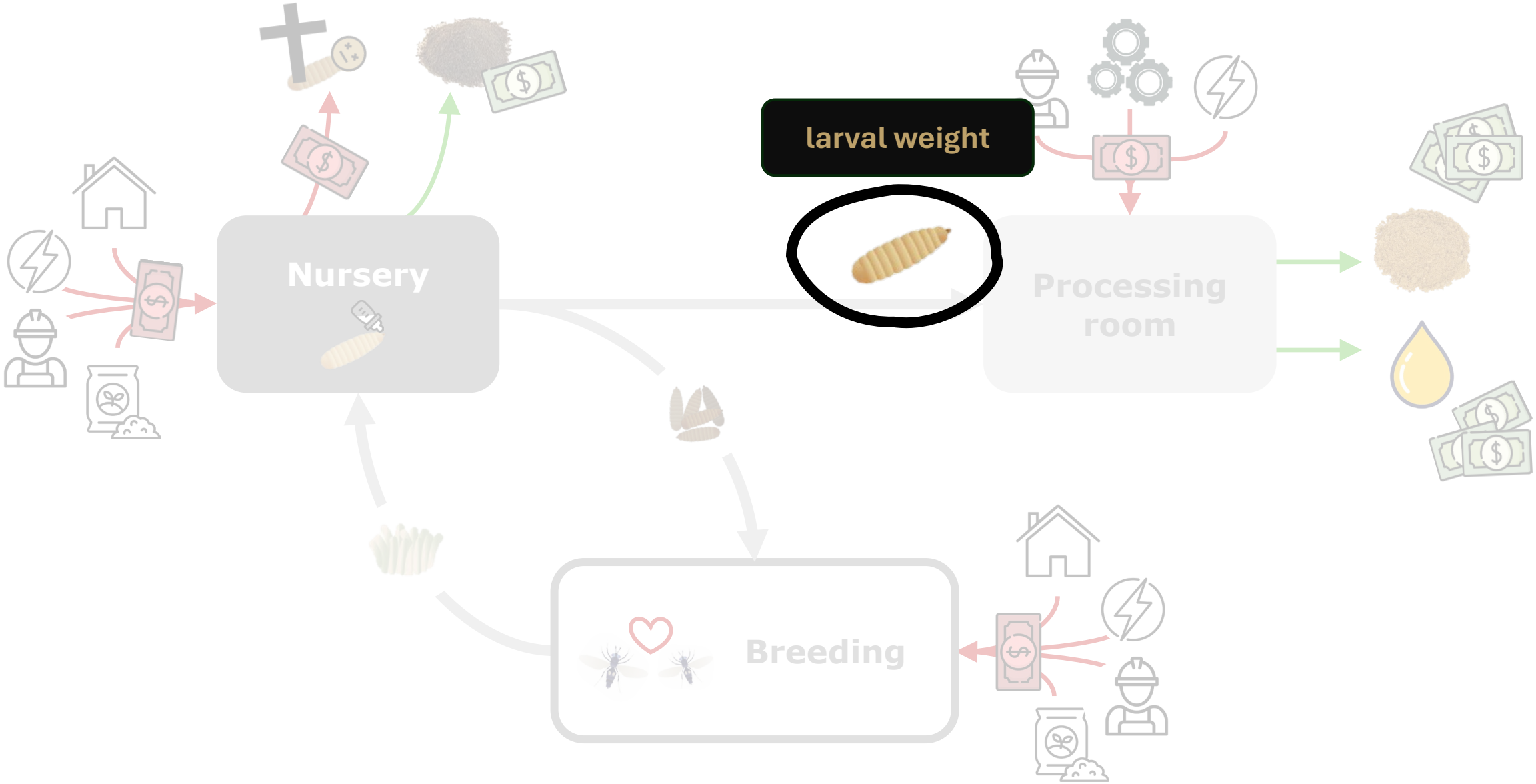
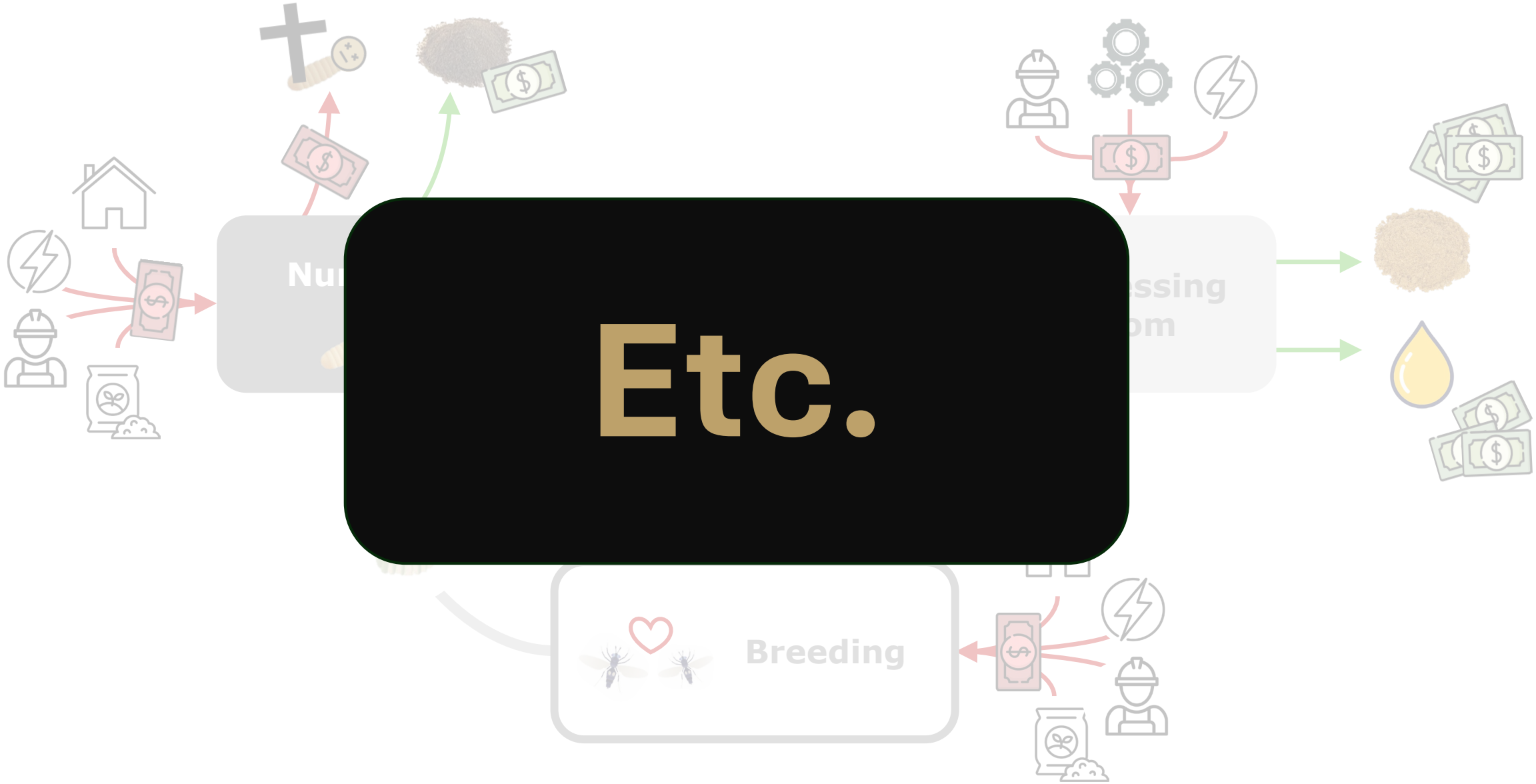

Nursery
Processing room
Breeding


Nursery
Processing room
Breeding
If the survival of flies is improved by 10%,
how much will the profit of the system increase?


Nursery
Processing room
Breeding
egg hatching rate


larval survival
Nursery
Processing room
Breeding


larval weight
Nursery
Processing room
Breeding


Etc.
Breeding

Traits

Wet larval mass on day 15	0.200 g
Dry matter FCR to wet larval mass	0.200 g
Growth rate	0.013 g/day
DM content	30%
Protein content	45%
Fat content	25%
Time (egg hatching to harvesting)	15 days

Time (pupae to reproduction)	13 days
Egg hatching rate	80%
Larval mortality rate from egg hatching until day 15	30%

Input for model

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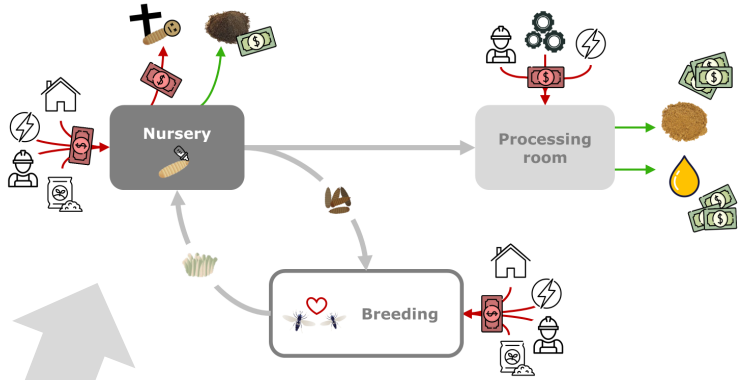
Prices



Costs

Results

		Economic value
Wet larval mass on day 15	0.200 g	30,89 €
Dry matter FCR to wet larval mass	0.200 g	-28,75 €
Growth rate	0.013 g/day	61,39 €
DM content	30%	88,71 €
Protein content	45%	67,38 €
Fat content	25%	21,33 €
Time (egg hatching to harvesting)	15 days	-33,54 €
Time (pupae to reproduction)	13 days	-5,23 €
Egg hatching rate	80%	4,76 €
Larval mortality rate from egg hatching until day 15	30%	-15,22 €

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IF **0.2** gr → **0.22** gr

*per **ton** of larvae*

+30,89 €

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Growth rate	**0.013 g/day**	**61,39 €**	Focus on **composition** & **growth**?
DM content	**30%**	**88,71 €**	
Protein content	**45%**	**67,38 €**	FIRST, we'll need more information…
Fat content	25%	21,33 €	
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Conclusions

The first economic values estimated for an insect species.

First step towards advanced selective breeding in insects.

What's next?

1 Estimate the genetic parameters for important BSF production traits.

2 Use these estimates for optimizing the economic value estimation.


Thanks for your attention

Extra slides

Variables and values used as input in the bio-economic model. Row 1-12 are population means, row 13 is a hypothetical mean, and row 14-19 are costs and prices.

	Variable	Unit	Value	Value + 10%
1	Mass at harvesting wet larvae	g/larva	0.200	0.220
2	Total dry matter feed intake	g/larva	0.200	0.220
3	Feed conversion ratio	kg/1 kg larvae on day 15	1.000	1.100
4	Growth rate	g/day	0.013	0.014
5	Dry mass content	%	30	33
6	Protein content	%	45	49.5
7	Fat content	%	25	27.5
8	Time (egg hatching to harvesting)	Days	15	16.5
9	Time (pupae to reproduction)	Days	13	14.3
10	Eggs per fly	#	780	858
11	Egg hatching rate	%	80	88
12	Larval mortality rate from egg hatching until day 15	%	30	33
13	Number of females mated to one male	# females	2	–
14	Protein	€/kg	2.840	–
15	Fat	€/kg	4.990	–
16	Feed (dry matter)	€/kg	0.200	–
17	Processing	€/kg of larvae on day 15	0.051	–
18	Housing and labour (egg hatching to harvesting)	€/kg of larvae on day 15	0.340	–
19	Housing and labour (pupae to reproduction)	€/kg of larvae on day 15	0.052	–

Output of the bio-economic model. The economic values, and proportional change in revenues (R), processing costs (C_p), maintenance costs for larvae ($C_{m,larvae}$) and flies ($C_{m,flies}$), and feeding costs for larvae (C_f) for each trait. Values are based on a system that produces 1000 kg of harvested larvae (wet mass)

Scenario [1]	Profit	R	C_p	$C_{m,larva}$	$C_{m,flies}$	C_f	Economic value (€)
Standard (€)	161	887	51	335	52	288	
Scenarios with +10%							
Larval mass on day 15	+19%	0	0	0	−8%	−9%	30.89
Total DM feed intake	−18%	0	0	0	0	+10%	−28.75
DM FCR to wet larval mass	−18%	0	0	0	0	+10%	−28.75
Growth rate	+38%	0	0	−9%	−8%	−9%	61.39
DM content	+55%	+10%	0	0	0	0	88.71
Protein content	+42%	+8%	0	0	0	0	67.38
Fat content	+13%	+2%	0	0	0	0	21.33
Time (egg hatching to harvesting)	−21%	0	0	+10%	0	0	−33.54
Time (pupae to reproduction)	−3%	0	0	0	+12%	0	−5.23
Eggs per fly	+3%	0	0	0	−8%	0	4.76
Egg hatching rate	+3%	0	0	0	−8%	0	4.76
Larval mortality rate from egg hatching until day 15	−9%	0	0	0	+6%	+4%	−15.22

Pictures

Link to pictures

- Cattle
  - Dairy cattle - Aquarell https://www.outdoorhappens.com/best-cow-for-milk/
  - Beef cattle - Aquarell https://www.outdoorhappens.com/black-and-white-cow-breeds/
- Chicken
  - Aquarell https://t3.ftcdn.net/jpg/04/54/48/88/360_F_454488874_1hbCsZpznvy3YGSWEQizA5wrnny4wUsm.jpg
- Pig
  - Aquarell https://stock.adobe.com/dk/images/watercolor-single-wild-boar-pig-animal-isolated-on-a-white-background-illustration/284841574
- Trout
  - Aquarell https://www.amazon.com/Watercolor-Art-Artist-DJ-Rogers/dp/B00RM7EWR6
- Grain
  - Wheat aquarell https://t3.ftcdn.net/jpg/02/67/92/92/360_F_267929227_ZjkQk3SPMPVLe7ULkVPcz08CwSgcIDBh.jpg
- World map
  - https://decolonialatlas.wordpress.com/2015/03/11/global-agriculture-where-we-grow-what-we-grow-and-how-we-grow/
- BSF
  - https://commons.wikimedia.org/wiki/File:202204_Black_soldier_fly.svg