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Presented by:

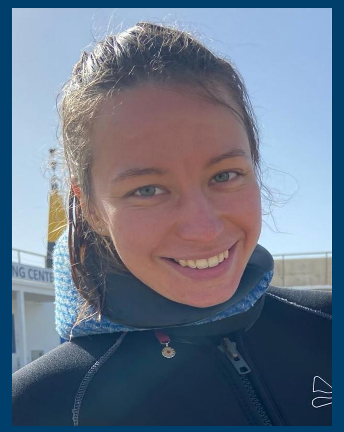

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Fig. 1: Black Soldier Fly with a crippling wing

Moving into a more sustainable future with the Black Soldier Fly - Black Soldier Fly larvae as a substitute product to fish oil & meal in the aquaculture industry

Fig. 9: Black Soldier Fly Larvae Pupae Stage

Current situation?

Currently, fish pellets are constituted of fishmeal and -oil derived from small pelagic fish such as anchovies and sardines, whose overfishing already have negative impacts on the environment[1]. To prevent the need and processing of these species a replacement which is similar in protein and lipid content needs to be found.

WHY Black Soldier Fly Larvae (BSFL)?

- ✓ The Black Soldier Fly Larvae is an omnivorous insect feeding on a variety of organic matter, resulting in a sustainable and high valuable product
- ✓ Depending on the food input during larvae stage their fat and protein content is even higher than in fish pellets [2],[3]
- ✓ Cultivation requires only little space
- ✓ Diseases can not be spread due to the absence of a mouthpart during the fly stage
- ✓ Easy cultivation and fast reproduction
- ✓ The fly is native in tropical regions

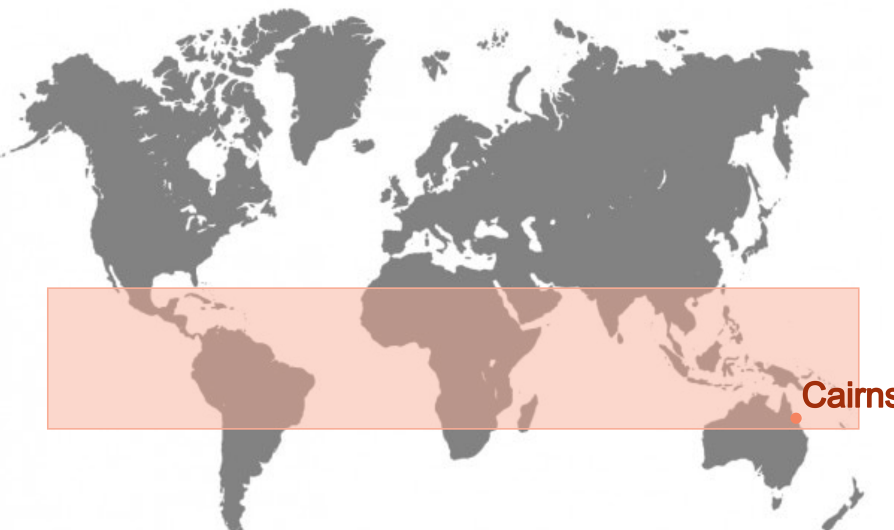

Fig.2: World map; source: [4]

Cultivation

Two cultivation setups: a) cage and b) compost were used to investigate the reproduction and growth. The temperature and humidity were monitored with the Govee Hydrometer. Corrugated cardboard was placed above substrate to attract female flies for oviposition

a) Cage (110x 80x50cm) | b) Compost

Fig. 3: Cage (left) with two rearing containers (right) filled with 1) Fruits and 2) Mix of vegetables for rearing BSFL. Cage location provides sunlight in the morning for 3.5 hours, and prevents overheating for larvae and flies in the afternoon

Fig. 4: Compost with 2 levels and a drainage system for the resulting liquids

Cage vs. compost cultivation

Cage cultivation

+ Enclosed system (protection from predators such as geckos and birds)
+ Easy to measure growth and cycle duration due to the multiple self-harvesting boxes

- Limited space for flies to mate
- Not self-sufficient since flies need wet environment → cage need to be kept moist 3x a day
- Temp. and light optimum for flies and larvae vary → small cage not suitable for coexistence in outdoor environments since either a sunny location is optimal for flies but to hot for larvae or shady location results in no reproduction
- Container need to have a good air flow to prevent mold on the surface of the substrate

Compost

+ Independent cultivation location for the compost within temperature optimum for larvae → the flies can mate at optimal sunlight/ wavelength nearby
+ Less maintenance, low budget and energy efficient → closer to natural behaviour
+ All larvae stages in one container → for each larva stage the perfect food source available

- Open system → predators such as birds, frogs, geckos, wallabies can feed on the larvae and substrate
- Hard to evaluate the cycle duration of the flies

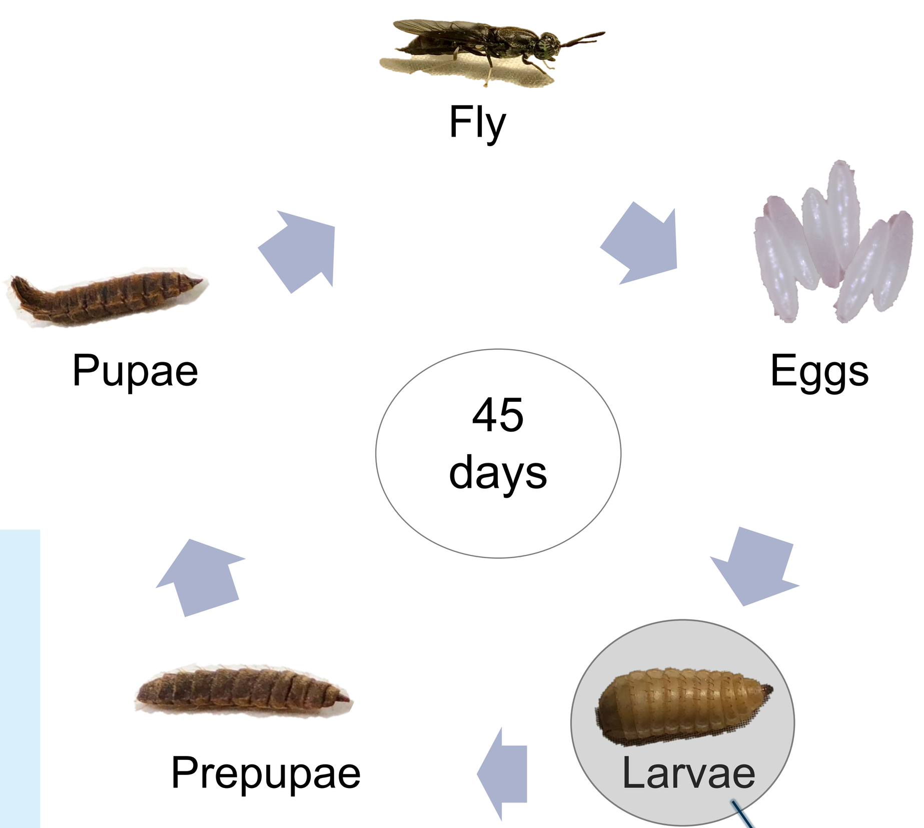

Fig. 5: Black Soldier Fly Life Cycle

Processing

The organic waste was shredded using a conventional kitchen machine to the smallest possible size before feeding to the larvae. The moist content of substrate was kept between 70-80% (either water was added or drained through the drainage holes).

The cultivated larvae were further processed and turned into pellets using the same conventional kitchen machine. First, the larvae were grinded to obtain a powder (or BSF meal) and then in the second step mixed with a)Oats b) Flour and c) MIX (different flours) to obtain pellets.

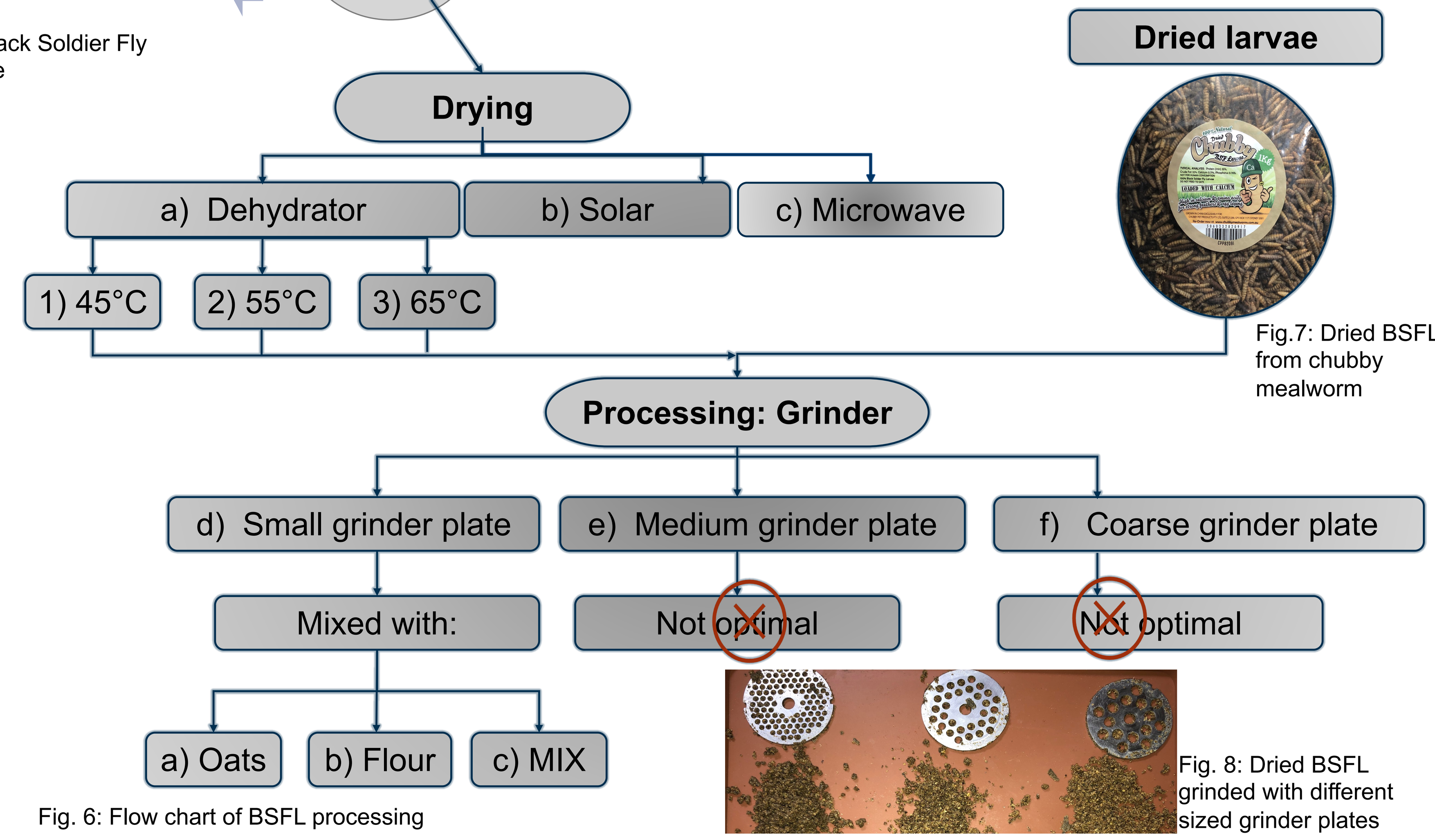

Fig. 6: Flow chart of BSFL processing

Fig.7: Dried BSFL from chubby mealworm

Fig. 8: Dried BSFL grinded with different sized grinder plates

Results & Discussion

Cultivation

- The temperature was between 11.4°C (minimum at night) and 27.8°C (highest during the day) and the humidity was on average 80.9% during the cultivation in the cage. This is withing a normal range. However, a reproduction in the cage was unsuccessful, probably due to:
  - a) insufficient water uptake during the fly stage. Regarding Nakamura et al.[5] the flies life span can be extended by providing sugar.
  - b) not the optimal wavelength or a lack of sunlight for mating. The cage was only in the sun in the morning hours until midday to prevent overheating for the larvae.
  - c) The fly density was not high enough. Maximum flies counted in the cage was 132. However, Nakamura et al.[5] achieved reproduction in a smaller cage (27 x 27 x 27cm) with 100 flies.

- The cultivation in the compost, however, was more successful resulting in at least 5-7 egg clutches per week. The temperature near the compost was not measured. Present flies were probably mating in the surrounding area (flies were not seen during the day) and attracted by the smell of the compost for oviposition.
- After a few weeks a mass mortality was noticed, probably due to
  - a) A lack of oxygen or insufficient ventilation within the two layers
  - b) Higher temperatures by larval aggregation → Death and crippling malformation (as seen in Fig.1 for a BSF) at temperatures above 40°C is reported by Chia et al. [6] However, Green et al. [7] assume positive effects due to higher bacterial densities and their release of beneficial nutrients for the BSFL. Nevertheless, the dead crowded larvae found in the compost indicated that oxygen might be the cause for mass mortality.

Processing

Solar drying didn't work well due to predators feeding on the larvae. The microwaved product was crunchy and puffed and the dried product can be fed directly to fish and poultry. Larvae dried in the dehydrator resulted in less voluminous and crunchy larvae and further processing is needed to increase its market value. Valuable products such as BSF oil, meal and pellets can be obtained. Further processing also allows longer storage of up to 6 months if the water activity is lower than 0.4 (lower than 0.6 inhibits growth for bacteria and yeast).[2]

Fig. 10: Conventional kitchen machine (meat grinder)

Summary:

This project has shown that the cultivation is easily achievable with low costs and effort in tropical areas. If the aim is a short term storage and subsequent feeding to fish and poultry the cultivation can be done in a compost. Further processing can be done with basic kitchen machines such as a meat grinder and a conventional dehydrator. For long term storage, however, it is recommended to defat the larvae prior to pelletizing. This increases the storage time up to 6 months, which is of more interest for e.g. the aquaculture industry.

Sources:
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[3] Johanna Naynar (2017). Verwertung biogener Abfälle mithilfe der Larven der Schwarzen Soldatenfliege (Hermetia illucens) zur Produktion von Futtermitteln
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[5] Nakamura et al. (2015). Small-scale rearing of the black soldier fly, Hermetia illucens (Diptera: Stratiomyidae), in the laboratory: low-cost and year-round rearing
[6] Chia et al. (2018). Threshold temperatures and thermal requirements of black soldier fly Hermetia illucens: Implications for mass production
[7] Green et al. (2002). Does the size of larval groups influence the effect of metabolic inhibitors on the development of Phormia regina (Diptera: Calliphoridae) larvae?

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Acknowledgment:

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