Why Black Soldier Fly (BSF)

The reason for choosing BSF is quite simple really - they are incomparable when it comes to turning food waste into protein suitable for use in animal feed.

In many ways, the choice of why BSF, as opposed to other species of insect, is very similar to the question of why a farmer would choose to farm cattle instead of buffalo (or other breeds of animal) for example. The decision is made according to the prevailing environmental, resource and market and technological conditions.

In this instance, BSF have been chosen for the following reasons:

- Ability to turn food waste into protein - essential decomposers
    - 1.5 kg food - 1kg larvae (compare 2kg food - 1kg mealworms)
    - Eat approx 2x body weight p/d
    - Approx 35% protein on harvest
- Can use food waste streams not suitable for other insect species
    - Eg fatty/oily/liquidy type foods that crickets/mealworms etc can't consume
- Sanitary - break down bacteria through feeding process
    - No bacteria in waste once digested
    - Non-disease vector (adult flies do not feed - therefore don't spread disease)
- Produce odour that repels other household pest species (flies/roaches/etc)
- Low space requirements
    - Thrive in high density
    - 1t BSF larvae can be produced in approx 6 sq/m
- Relatively low production requirements
    - 'Easy to farm'
    - Don't 'escape' easily
- Ability to mass produce
    - Rapid reproduction
        - 1 female lays approx 500 eggs
- Non pest species
- Naturally occurring across SSA

- Approx 45 day life cycle
    - 11 days fly
    - 5 days egg
    - 17 days larvae
    - 12 days pupae
- Produce high quality frass (insect manure)
    - Ideal fertilizer for plant growth
        - Good N:P:K balance (3:2:4)
        - High in other minerals/macro/micro nutrients

In addition to these aspects, BSF have quickly become the #1 insect for animal feed species on the global agenda.

- Massive investments over the last 5 years
    - eg, AgriProtein's recent $105m capital raise
    - or Protix's $50
- In response to:
    - Increased consumer and investor awareness
    - Real world demonstration of commercial potential
- Contains Chitin (exoskeleton)
    - Natural antimicrobial peptides
        - Assist in animal health promotion
            - Supports natural immune defence
        - Reduces need to use antibiotics in animal feeds
- Rapid rise in market demand
    - Particularly driven by aqua feed market
        - Alternative to fish meal (cost effective (+ sustainable) substitute
    - Also large drive from poultry industry
        - Cost cutting opportunity

Other insect species considered

Before deciding to focus on the production of BSF for animal feed, a number of other insect species were assessed as alternatives

A list of these are given, along with some of the main benefits and drawbacks, as well as the conclusion that was drawn regarding their suitability: This analysis was done in comparison to BSF as a source of protein for animal feed.

A note - the specific focus at this stage of Nambu's development is on our capacity to enter the feed protein market, as it presents a larger existing opportunity than *Entomophagy* (the human consumption of insects), which is still in its infancy, at least in Western Markets. We do believe in building capacity to produce insect protein for human consumption, however, we see this as best placed off the back of an existing commercial capacity to produce insects for animal feed. The main reason for this being the more immediate market opportunity that exists, and lower barriers to consumer acceptance (as you don't have to convince a chicken that a worm is good for it to eat).

The points listed below were gathered through a combination of desktop research and one-on-one interviews with various Entomologists and other professionals working in this space.

Species	Benefits	Drawbacks	Conclusion
Crickets	• High feed conversion ratio • Good nutrient profile • Acceptance for Human Consumption	• Longer production lifecycle • Require higher grade feed (eg chicken feed) • Larger space requirements	Not as suitable as BSF for feed production. Better suited for Entomorphagy
Mealworms	• Can use low grade feed • Acceptance for Human Consumption	• Longer production lifecycle • Rely on grains as major feed source • Not as efficient feed conversion	Not as suitable as BSF for feed production Better suited to Entomorphagy
Grasshoppers	• Ability to turn cellulose (eg grass) into protein • Acceptance for Human Consumption	• Longer production lifecycle • Require constant supply of fresh greens (logistics challenge) • Larger space requirements	Not as suitable as BSF for feed production Better suited to Entomorphagy
Mopane Worm	• Existing food item in parts of RSA + SSA • Indigenous + relatively undeveloped commercial production/ market	• Seasonal • Restricted to Northern parts of RSA • Wild collected (commercial production is difficult and relies on mature Mopane Trees which take time to grow)	Not as suitable as BSF for feed production Better suited to Entomorphagy

The conclusion drawn from this analysis is that the BSF presents the largest commercial opportunity in the immediate term, with space for further development (ito insect species produced) to follow off the back of this capacity.

Lifespan comparison

Insect Species	Lifespan
BSF	45 Days
Mealworms	65 Days
Crickets	85 Days

Nutrient comparison tables

NUTRITIONAL VALUES	BSFL Meal	Cricket Meal
Crude Protein (%)	55	59
Fat (%)	15	24
Carbohydrates + Fiber (%)	17	14.4
Ash (%)	8	6.5
Energy (Cal/100g)	400	472
Sodium (ppm)	1245	310000
Calcium (ppm)	15000	110000
Magnesium (ppm)	4171	-
Phosphorus (ppm)	8812	-
Potassium (ppm)	14508	1100000
Iron (ppm)	277	2000
Zinc (ppm)	143	-
Copper (ppm)	15	-
Selenium (ppm)	1	-
Manganese (ppm)	349	-
Molybdenum (ppm)	1	-
B12 (ug)	-	24
Omega – 3 (%)	1.4	2.8
Omega – 6 (%)	0.2	6.3

Source: https://northernhound.com/blog/super-protein-nutritional-information-of-crickets-black-soldier-fly-larvae-bsfl/

Amino Acids	Units	BSFL Meal	Cricket Meal
Crude Protein	g/100g	55	59
Alanine	g/100g	3.7	4.7
Arginine	g/100g	3.0	3.9
Aspartic Acid	g/100g	5.9	4.7
Cystine	g/100g	0.8	0.4
Glutamic Acid	g/100g	6.4	5.8
Glycine	g/100g	3.5	2.8
Histidine	g/100g	1.9	1.0
Isoleucine	g/100g	2.2	2.3
Leucine	g/100g	4.2	4.0
Lysine	g/100g	3.8	2.3
Methionine	g/100g	1.2	0.9
Phenylalanine	g/100g	2.3	1.8
Proline	g/100g	3.4	3.2
Serine	g/100g	2.4	2.6
Threonine	g/100g	2.4	2.1
Tryptophan	g/100g	0.9	2.9
Tyrosine	g/100g	3.8	0.5
Valine	g/100g	3.7	3.2
Fatty Acids			
Omega – 3	g/100g	1.4	2.8
Omega – 6	g/100g	0.2	6.3

Source: https://northernhound.com/blog/super-protein-nutritional-information-of-crickets-black-soldier-fly-larvae-bsfl/

Insect	Life stage	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber * (%)	Calcium (mg/kg)	Phosphorus (mg/kg)	Thiamin (mg/kg)
House crickets	Adults	69.2	20.5	6.8	1.1	3.2	407	2,950	0.4
House crickets	Nymphs	77.1	15.4	3.3	1.1	2.2	275	2,520	0.2
Mealworms	Larvae	61.9	18.7	13.4	0.9	2.5	169	2,850	2.4
Superworms	Larvae	57.9	19.7	17.7	1.0	2.7	177	2,370	0.6
Waxworms	Larvae	58.5	14.1	24.9	0.6	3.4	243	1,950	2.3
Silkworms	Larvae	82.7	9.3	1.1	1.1	1.1	177	2,370	3.3
Butterworms	Larvae	60.2	15.5	29.4	0.8	1.4	125	2,250	0.7
Soldier Flies	Larvae	61.2	17.5	14.0	3.5	3.0	9,340	3,560	7.7
Fruit flies	Adults	69.1	21.0	5.9	3.1	2.2	526	4,080	0.9
Turkestan Roaches	Nymphs	69.1	19.0	10.0	1.2	2.2	385	1,760	Not analyzed
Six-spotted cockroaches	Nymphs	50.8	18.8	26.8	Not analyzed	1.0	295	1,820	Not analyzed
Madagascar hissing cockroaches	Nymphs	69.2	19.5	6.3	4.0	2.6	771	2,870	Not analyzed

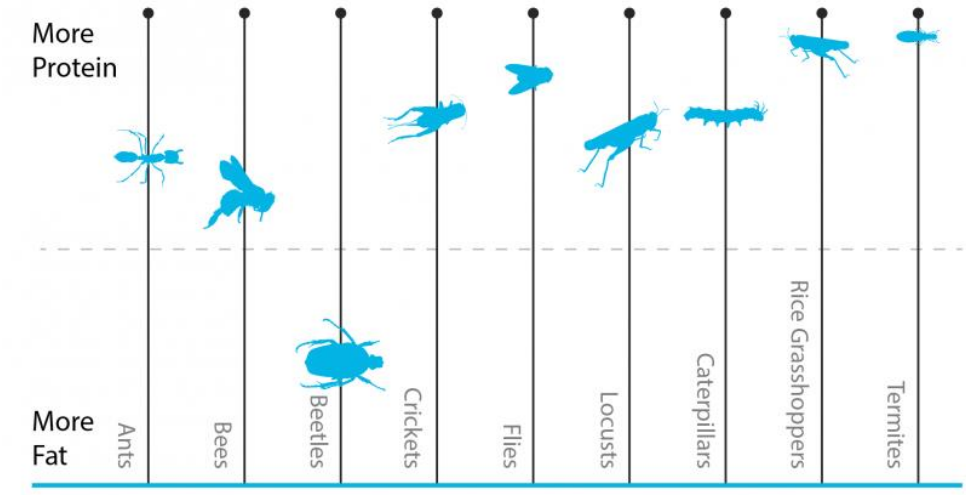
* - Fiber measured as acid detergent fiber.

Source: https://thewormlady.ca/exotic-pet-nutritional-info.php

Nutrition Facts

Per 100 grams of cooked weight	Mealworms	Crickets
	Roasted	**Boiled, roasted**
Calories	436	472
Protein	55.43 g	58.51 g
Fat	18.9 g	24.0 g
Saturated	4.13 g	8.48 g
Monounsaturated	6.48 g	5.14 g
Polyunsaturated	7.33 g	9.09 g
Omega-6	7.03 g	6.28 g
Omega-3	0.297 g	2.81 g
Carbohydrates	15.4 g	8.4 g
Sugars	0.5 g	0.4 g
Dietary fiber	8.7 g	6 g
Cholesterol	149 mg	228 mg
Vitamin A	620 IU	no data
Calcium	810 mcg	1100 mcg
Iron	37 mcg	25 mcg
Potassium	11 mg	11 mg
Sodium	1.8 mg	3.1 mg

Source: https://www.precisionnutrition.com/eating-bugs



Source: https://www.precisionnutrition.com/eating-bugs

Additional Sources:

https://www.eatcrickster.com/blog/black-soldier-fly

https://northernhound.com/blog/super-protein-nutritional-information-of-crickets-black-soldier-fly-larvae-bsfl/

https://www.kisorganics.com/products/natural-insect-fertilizer-frass

This is a particularly useful doc as it highlights many of the points that Nambu is addressing via our distributed approach to business development:
https://divertns.ca/assets/files/Production-of-High-Value-Protein-Feeds-and-Fertilizer-from-Pre-Consumer-Vegetable-Waste-Utilizing-a-Novel-Black-Soldier-Fly-Larvae-Conversion-Process-%E2%80%93-Dr.-Beth-Mason-2016.pdf

Also very good for general info on BSF
https://www.feedipedia.org/node/16388