NUFFIELD
Farming Scholarships

Building A Black Soldier Fly Industry In The UK

Written by:

David Tavernor NSch

August 2025

A NUFFIELD FARMING SCHOLARSHIPS REPORT

KINDLY SPONSORED BY:

Alan and Anne Beckett

NUFFIELD FARMING SCHOLARSHIPS TRUST (UK)

Awarding life changing Scholarships that unlock individual potential and broaden horizons through study and travel overseas, with a view to developing farming and agricultural industries.

"Leading positive change in agriculture"

"Nuffield Farming" study awards give a unique opportunity to stand back from your day-to-day occupation and to research a subject of interest to you. Academic qualifications are not essential, but you will need to persuade the Selection Committee that you have the qualities to make the best use of an opportunity that is given to only a few – approximately 20 each year.

Scholarships are open to those who work in farming, food, horticulture, rural and associated industries or are in a position to influence these industries. You must be a resident in the UK. Applicants must be aged between 25 and 45 years (the upper age limit is 45 on 31st July in the year of application).

There is no requirement for academic qualifications, but applicants will already be well established in their career and demonstrate a passion for the industry they work in and be three years post tertiary education. Scholarships are not awarded to anyone in full-time education or to further research projects.

Full details of the Nuffield Farming Scholarships can be seen on the Trust's website: www.nuffieldscholar.org. Application forms can be downloaded and only online submission is accepted.

Closing date for completed applications is the 31st July each year.

ISBN: 978-1-916850-35-4

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
Email: office@nuffieldscholar.org
www.nuffieldscholar.org

A NUFFIELD FARMING SCHOLARSHIPS REPORT (UK)

Date of report: March 2025

NUFFIELD Farming Scholarships

"Leading positive change in agriculture. Inspiring passion and potential in people."

Title	Building A Black Soldier Fly Industry In The UK
Scholar	David Tavernor
Sponsor	Alan and Anne Beckett
Objectives of Study Tour	1. A realistic assessment of the BSF landscape in both global and UK contexts. 2. Suggestions for successful approaches in today's market. 3. A roadmap for building a thriving UK BSF industry that balances innovation with practicality.
Countries Visited	Brazil, Argentina, Chile, USA, Canada, UK, Denmark, Germany, Netherlands, Finland, South Africa, Kenya, Rwanda & Tanzania
Messages	• BSF farming is commercially viable but human-driven barriers (regulation, supply chain gaps, and industry attitudes) currently prevent widespread adoption. • Regulatory constraints in the UK limit feedstock options and product applications, making profitability difficult. • Many in the industry are supply-focused, not demand-driven—scaling production alone will not create a market. • Collaboration is key—protecting IP and working in isolation is slowing industry progress. • BSF farming is still in its early stages—businesses and investors must remain agile rather than committing to rigid models too soon. • The long-term vision is clear—BSF can play a major role in global food systems, but only if today's challenges are addressed through a 20-year roadmap.

EXECUTIVE SUMMARY

Black Soldier Fly (BSF) farming is emerging as a promising solution to two major challenges—sustainable protein production and organic waste management. The potential for profitability is clear, with BSF converting low-value waste into high-value products such as animal feed, insect oil, and organic fertiliser. However, despite its strong economic fundamentals, widespread adoption is being held back by regulatory barriers, underdeveloped supply chains, and business models that both fail to prioritise commercial viability and encounter crippling technical challenges. BSF farming directly impacts 8 United Nations Sustainable Development Goals, so the reason for farming BSF is well understood. However, the industry itself remains in its infancy, struggling to establish the right conditions for success.

Information has been gathered from a global study tour spanning 14 countries, analysing how BSF farming has developed under different conditions. Some regions have made progress by allowing feedstock flexibility and prioritising market development, while others remain constrained by policy uncertainty and fragmented industry efforts. The UK, in particular, has been slow to progress, with strict regulations limiting feedstock availability and product applications; high operational costs preventing competitive production; and a lack of coordinated supply chain infrastructure.

One of the key challenges holding the industry back is the prevailing attitudes within the trade. Many businesses assume that once supply is established, demand will naturally follow. However, generating consistent demand requires much more than simply producing BSF products at scale. Feed manufacturers, farmers, and end users need clear commercial benefits, yet many BSF businesses fail to effectively communicate their value proposition. Similarly, there is a tendency to focus on protecting intellectual property rather than fostering industry-wide collaboration, which has contributed to fragmentation and slow market adoption.

Despite these challenges, the long-term future of the industry is bright. However, unlocking large-scale adoption will require more than just technical feasibility, it demands a coordinated effort across policy, industry, and investment. Regulatory frameworks must evolve to allow broader feedstock use and expanded market applications; supply chains need to be developed; businesses must shift toward customer-driven strategies; and government incentives will be crucial in accelerating early-stage adoption.

The industry does not need more justification for its existence, it needs a roadmap to commercial viability. The lessons gathered from international case studies, combined with a deeper understanding of the UK's constraints, provide a blueprint for how to build a BSF sector. It's not the insects that need to be convinced. It's us. The success of BSF farming will be decided by those willing to align regulation, investment, and strategy with commercial reality.

TABLE OF CONTENTS

DISCLAIMER

The opinions expressed in this report are those of the author alone and not necessarily those of the Nuffield Farming Scholarships Trust, of the author's sponsor, or of any other sponsoring body.

CONTACT DETAILS

David Tavernor

Shropshire, UK

David@fly2feed.com

www.fly2feed.com

https://www.linkedin.com/in/david-tavernor-fly2feed/

Nuffield Farming Scholars are available to speak to NFU Branches, agricultural discussion groups and similar organisations.

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
email : office@nuffieldscholar.org
www.nuffieldscholar.org

CHAPTER 1: PERSONAL INTRODUCTION

Figure 1: Author David Tavernor.

I was wandering down a vibrant street in a lively town in the Sierra Madre mountains of Southern Mexico on a backpacking trip eight years ago and I found myself in the heart of a bustling street food market. Among the myriad of colours, sounds, and smells, one delicacy caught my eye: chapulines, or, if you speak English, roasted grasshoppers. Intrigued, I watched locals and tourists alike snack on these crispy insects, seasoned with lime and chilli. It was here, amidst the lively chaos of the market, that I first learned the potential of insects' role in food. But it is more than just a novelty for human consumption. Beyond their culinary appeal, I began to imagine the possibilities for insects as a vital agricultural input, paving the way for a more sustainable food system.

Growing up on a dairy farm in Shropshire, I built the foundational learning of agriculture and business. My father, Roly, a 2001 Nuffield Scholar, was a constant source of inspiration. As he ripped up the British dairy model and replicated the New Zealand model in the UK, I developed a keen interest in understanding how to evolve to meet the challenges of a changing world. The values of hard work and innovation were ingrained in me during these formative years. Crucially, I understood the value of contrarianism.

Building on this foundation, I pursued formal education in business and agriculture. After completing a year-long course in Enterprise and Entrepreneurship at the Peter Jones Enterprise Academy in Manchester, I spent four years studying agri-business management at Newcastle University, with a year spent at Aldi on their industrial placement programme.

Following university, I gained valuable industry experience at Tesco, working primarily as a vegetable buyer, which offered a first-hand look at how supply chains can operate, despite thin margins. Later, I joined Gopuff, a London-based tech start-up and 'unicorn', delivering groceries to customers within minutes of their order being placed. This nine-month stint was a whirlwind experience, a 'rags-to-riches-and-back-to-rags-again' story, where I witnessed the highs and lows of tech start-up culture and gained insights into the workings—and failings—of venture capital investment. It was an intense education.

In 2022, after being made redundant by Gopuff, I returned to Shropshire to pursue my dream of starting an innovative business as a black soldier fly (BSF) farmer. I bought three shipping containers and began breeding and rearing BSF back on the farm. Over the past two years, I have been producing live BSF larvae, which I sell to a local broiler farmer to enrich their chickens' diet. The by-product of this process, insect frass, is marketed as a garden fertiliser. Alongside running this business, I work as a consultant in the BSF industry.

I recently visited Illtud Dunsford, a UK Nuffield Scholar who owns Cellular Agriculture, a cultivated meat business, and asked him his motivation. He told me he wants to add a new instrument to the global toolbox in tackling some of the world's problems, and I resonate with this. I am motivated by curiosity, by problem solving and a responsibility to be better every day. If BSF can solve problems, then I want to help. To achieve this, I want to become a leader of business, thought and change in this industry. I hope that my findings in this report alters the approach to this industry for existing operators and new entrants for the good, and that they help to develop a thriving industry in the future.

CHAPTER 2: BLACK SOLDIER FLY FARMING

2.1 The State Of The Industry – Why BSF Production Is Needed

BSF farming is gaining global attention as a solution to some of agriculture's most pressing challenges. With its unique ability to address environmental, economic, and social concerns, BSF production has the potential to transform food systems sustainably.

Overall, BSF farming can operate across two industries. Firstly, it plays a role in waste management. BSF larvae (BSFL) are voracious eaters of organic waste, capable of diverting food and agricultural by-products away from landfills. By closing the loop on organic waste streams, BSF farming creates a circular economy, significantly reducing methane emissions and environmental degradation associated with conventional waste disposal methods.

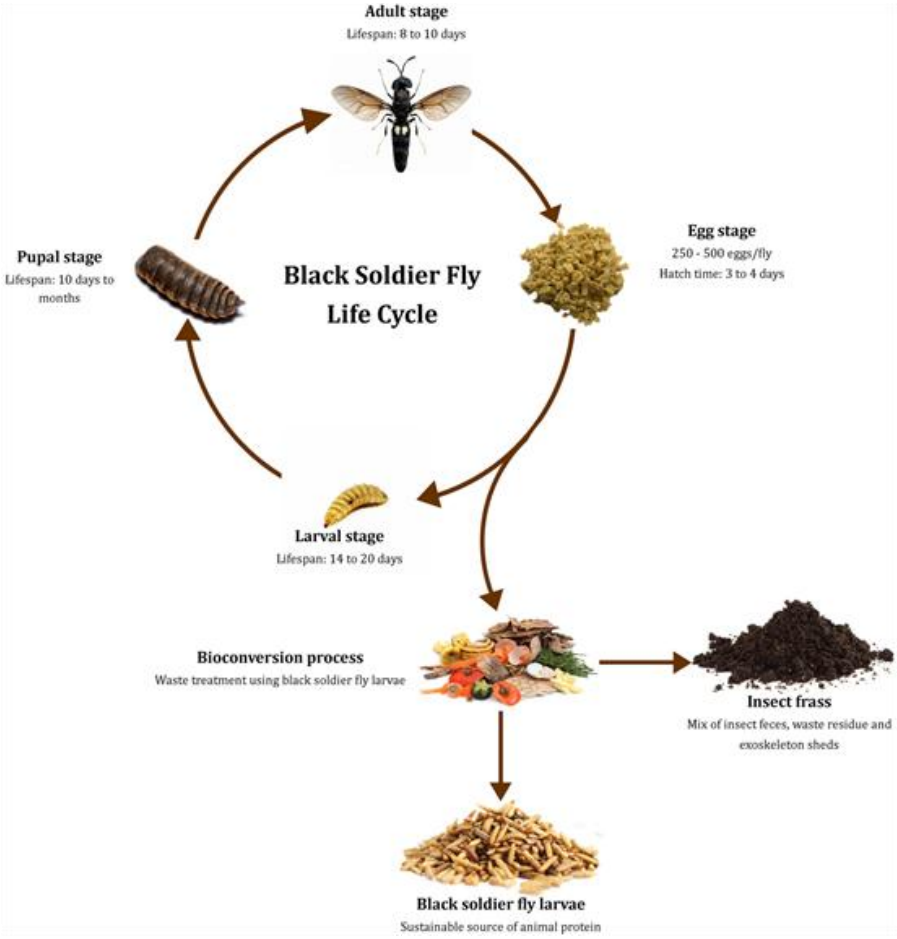

Figure 2: Black Soldier Fly Lifecycle.

Beyond waste management, BSFL and their manure (frass) are rich in protein, fat, and nutrients—ideal for use in livestock feed, fertiliser, pet food, pharmaceuticals, and biofuels. Their adoption reduces our dependence on environmentally intensive soy, fishmeal, synthetic fertilisers, and fossil fuels. With high levels of

chitin and antimicrobial peptides (AMPs), there are many reasons, nutritionally, to consider BSFL in animal feed.

Frass is a highly nutritious organic fertiliser, similar in macronutrients to chicken manure, but with a lower moisture content, less odour, and a lower risk of pathogens and heavy metal accumulation. It improves soil structure, enhances microbial activity, and provides an alternative to chemical fertilisers, contributing to regenerative agricultural practices.

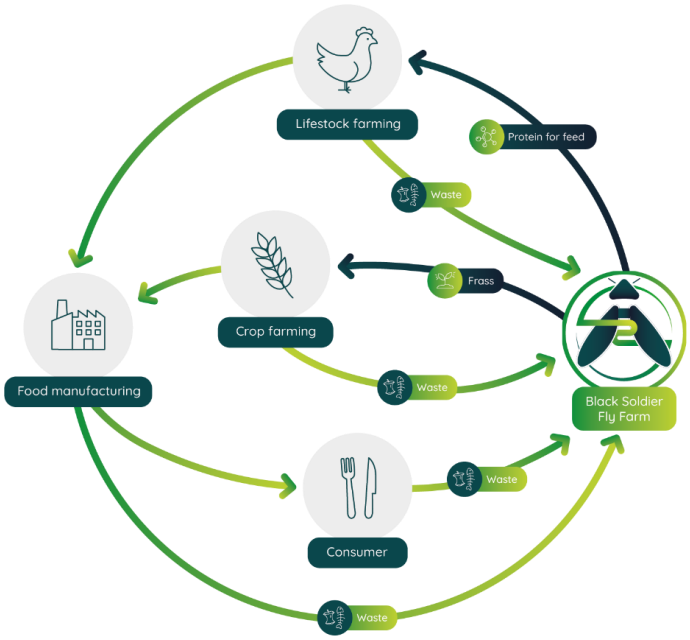

Figure 3: A circular economy according to the black soldier fly.

The stakeholders who benefit from BSF farming are diverse, with farmers, consumers, investors, and governments all interested. It's reasonable to suggest that BSF farming addresses eight of the UN Sustainable Development Goals directly, such is the diversity on offer.

Figure 4: UN Sustainable Development Goals directly impacted by BSF farming.

Despite its promise, the BSF industry faces significant challenges. High production costs, regulatory barriers, the lack of cohesive supply chains, and limited end-user understanding hinder widespread adoption. While these obstacles are formidable, they present opportunities for innovation and strategic problem-solving.

2.2 Framing This Report

The potential of BSF farming has been explored in previous Nuffield Farming Scholarship reports, providing a valuable foundation for this study. In 2022, Olivia Champion highlighted the environmental benefits of the circular insect farming process, when practised correctly. Champion's findings emphasized that while the concept of BSF farming is promising, current market conditions make scalability and profitability elusive. Similarly, George Roach's 2023 report focused on developing production systems but concluded that regulatory frameworks, particularly in the UK, stifle innovation and growth. Both scholars viewed insects positively, yet their analyses painted a sobering picture of the industry's current feasibility. Building upon their work, this report aims to provide actionable strategies and solutions that can pave the way for a more prosperous BSF industry.

Various market valuations anticipate the global BSF industry to achieve a spectacular compound annual growth rate of 24% up to 2030 (*Barclays Food Revolution*). This projected growth underscores the global recognition of the industry's potential to revolutionise sustainable agriculture.

However, a crucial question remains: how does one thrive in an industry where survival itself seems improbable?"

2.3 Study Objectives

New and promising industries are often misunderstood and can be mismanaged, and the BSF world is no different. Many stakeholders' approach BSF farming with misconceptions, underestimating costs, overcomplicating production systems, failing to adapt to local conditions, or neglecting the importance of effective product marketing.

This report serves as a practical guide to help the BSF industry overcome these barriers and unlock its potential. The aims of the report are to provide:

1. A realistic assessment of the BSF landscape in both global and UK contexts.
2. Suggestions for successful approaches in today's market.
3. A roadmap for building a thriving BSF industry that balances innovation with practicality.

My goal is to empower stakeholders to view BSF farming not as an idealistic solution but as a viable commercial opportunity. By embracing sound strategies

and fostering collaboration across the supply chain, I believe the industry can achieve sustainable growth and meaningful impact.

With optimism and a solution-oriented approach, this report aims to inspire confidence in BSF farming's ability to tackle global challenges and provide a clear pathway to success for all stakeholders involved.

CHAPTER 3: LESSONS FROM THE STUDY TOUR

3.1 My Study Tour

Over four months, I travelled to 14 countries across four continents—South America, North America, Europe, and Africa—to explore the development of the Black Soldier Fly (BSF) industry. My journey included visits to Brazil, Argentina, Chile, USA, Canada, UK, Netherlands, Germany, Denmark, Finland, South Africa, Kenya, Rwanda, and Tanzania. Each country provided a unique lens into how BSF farming is evolving under varying regulatory frameworks, economic conditions, climatic and cultural influences.

The purpose of this study tour was to investigate the diversity of production systems being implemented globally and the key factors shaping their success or failure. Regulatory environments emerged as a significant variable, with countries like the Netherlands leading in policy adaptation, while others, such as Kenya, leveraged less formalised approaches to foster innovation. Macro-economic conditions further underscored the contrasts between high-capital, automated facilities in Europe and low-cost, decentralised models in Africa.

South America was a key destination to understand the soy industry, the most widely used protein source in global animal feed. Visiting Brazil, Argentina, and Chile allowed me to explore the region's dominant role in the global protein market and its implications for BSF farming as a complementary or alternative solution.

In North America, I aimed to investigate how a region with similar climatic and economic conditions to the UK is approaching BSF farming within a different regulatory framework.

Summary of learnings:

1. It's hard to compete with commodity prices without scale.
2. Insect businesses can either be input-led or output-led.
3. Heavy automation removes the ability to adapt your model.
4. Identify niche markets and add value.
5. Collaborate, and specialise.
6. An insect farm doesn't necessarily equate to insect crates, robots, and big factories.
7. There is no playbook for insect production, we are writing it.

3.2 Learnings

South America

Figure 6: The author in a soybean field.

Figure 6: The author with Bram Dortmans at F4F, Chile.

South America, particularly Brazil, demonstrated the immense scale and efficiency of traditional agriculture. In Rio Grande do Sul, a visit to a soybean seed facility revealed the staggering scale of production, with drying areas rivalling the size of some of the largest BSF facilities visited later in the study tour. Despite this facility being considered "small" by Brazilian standards, the operation was a testament to the region's dominance in global protein markets. The facility's owner highlighted that drying soybeans cost only 3-5% of the final product's value—a figure starkly lower than the circa 15% drying cost in BSF farming. This efficiency underscores the competition alternative proteins face in regions where traditional agriculture is already optimized for scale and cost-effectiveness.

BSF farming in South America has not gained significant traction. High capital requirements and limited awareness about the emerging industry have slowed adoption. Moreover, the region's agricultural focus remains firmly on traditional proteins like soy, which are deeply integrated into global supply chains and enjoy strong demand. Despite these challenges, South America presents a compelling opportunity for BSF farming as part of a circular economy in the region's rapidly expanding agriculture industry.

Learning: It's hard to compete with commodity prices without scale.

North America

Figure 8: The author with Luis Ortiz, IHT, Canada.

Figure 8: Refeed, Canada. Waste collections in Canada.

In North America, the BSF industry appeared fragmented and less advanced compared to Europe. Visits to facilities in Canada and the USA revealed a heavy reliance on proprietary technologies and isolated innovation efforts.

Despite this, a visit to Infinite Harvest Technologies in Canada is where founder, Luis Ortiz, described the two predominant business models in the BSF industry: input-led and output-led. Luis realised that significant scale is required to sell protein to aquaculture. Instead, Luis generates gate-fee revenue by processing feedstocks with BSF. Sales of larvae and frass serves merely as supplementary income. Luis has a clear plan to pivot from an input-led gate-fee model to an output-led protein producer for the Canadian aquaculture market once his business reaches a critical scale.

Figure 9: Bug Mars, Canada. Will bugs make it to Mars?

The emphasis on developing unique technologies and business strategies, however, has led to limited collaboration between North American stakeholders. Facilities were often small-scale and lacked cohesion in their approach to scaling. Despite these limitations, North America's growing focus on Environmental, Social, and Governance (ESG) investments provide opportunities for scaling BSF farming with its environmental sustainability credentials. Partnerships and collaborative frameworks could enable the region to overcome its scalability challenges and unlock its potential for integrating circular economy farming solutions.

Learning: Insect businesses can either be input-led or output-led.

Europe:

Figure 10: ENORM Biofactory, Denmark.

Europe stood out for its ambitious investment in automation and advanced technologies. Facilities such as ENORM in Denmark, one of the largest BSF farms in the world producing 10,000 tonnes of insect meal per annum, exemplified the region's commitment to scaling the industry through cutting-edge systems. Built by pig and poultry equipment powerhouse Big Dutchman, ENORM's state-of-the-art ventilation technology virtually eliminated odour, while its automated production lines and robots optimized efficiency. However, the sheer scale of operations and high capital expenditure raised concerns about financial sustainability. The technology is complex, and any breakdowns cause bottlenecks in the process. When there is a consistent supply of feedstock input that needs to be processed, there is little wiggle room for slower production. Furthermore, the volume of BSF and frass produced must have an outlet, otherwise it is stockpiled at additional cost.

This production model is typical for many BSF start-ups across the world, but particularly in Europe, and the obsession with yield, marginal improvements and scale was best displayed at Insecta Conference in Berlin, a key gathering for the European BSF industry. Academics dominated the keynote sessions, presenting research and incremental advancements, while agri-tech companies, as major sponsors, showcased expensive and ambitious technologies. Informal discussions often centred on claims of having the largest larvae or the highest production capacities.

However, notably absent from the conference was a meaningful dialogue on the most critical topic: how to build a profitable business model in the BSF sector. Nevertheless, Europe's advanced market for sustainable products and strong ESG investment landscape make it a promising region for BSF farming.

Learning: Heavy automation removes the ability to adapt your model.

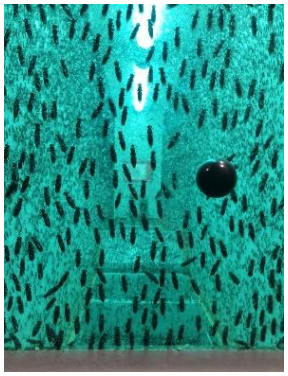
Figure 12: ENORM fly cage.


Figure 12: Farm Insect, Germany.

South Africa

Figure 15: Maltento neonate larvae.

Figure 15: Max Breitensteiner, Genbiosol.

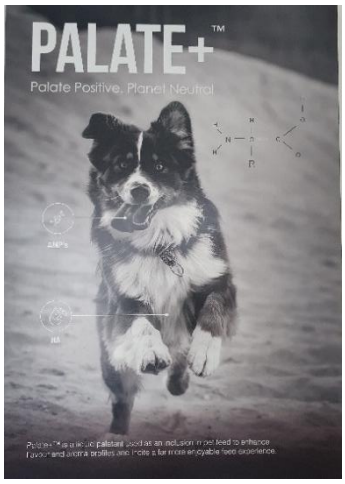

Figure 15: Maltento's Palate+ product.

Maltento, a large producer in Cape Town, highlighted the potential of developing high-value niche products, such as their "Palate+" supplement for pet food. Notice this is a supplement, rather than the bulk protein ingredient, for which you have to compete with meat by-products. The marketability of BSF protein uses a combination of nutritional benefits and a strong consumer narrative and when utilised as a supplement it enables Maltento to command higher margins, circumventing the price pressures of commodity markets.

Learning: Identify niche markets and add value.

The ecosystem of Cape Town offered a refreshing outlook after the frustrations experienced in Europe. The demise of the world's most high-profile start-up, Agriprotein (based in Cape Town), caused by the irresponsible expenditure of large piles of investor capital, encouraged individuals to collaborate and create a supply chain of many specialists, including breeders, tech providers, government, producers, and offtake developers.

The country also benefits from a growing interest in sustainability, with organic waste to landfill set to be banned in 2027 in the Western Cape province. A conversation with Sam Smout, who works at Greencape, a non-profit, revealed they are facilitating this move to a circular organic economy. Sam has reviewed all options, including biogas and composting, and insect bioconversion comes out on top.

Learning: Collaborate and specialise.

Figure 17: The old Agriprotein facility.

Figure 16: Insect processing.

East Africa

Figure 20: BSFL in Kenya.

Figure 20: Author in a fly room.

Figure 20: Chanzi, Tanzania.

East Africa focuses primarily on profitability by prioritising cost control and efficiency over speculative revenue growth. A simple example: Chanzi embodies this approach by locating near feedstock sources – one of their sites was within nose distance from the local landfill – and using innovative, low-tech systems that minimise labour hours, without the need for excessive automation or over-priced equipment. This enables early profit generation, avoiding the high-capital, long-payback strategies often seen elsewhere, where financial sustainability is compromised. Chanzi were the first visit on this tour whereby the leadership claimed to be able to compete with the soy protein price.

Figure 22: Landfill, Tanzania.

Proteen, another standout in East Africa and, ironically, the only company visited not focusing on the protein element of BSF, focused on integrating BSF production into the coffee supply chain. By using waste pulp from coffee wash stations, Proteen accelerated composting and created nutrient-rich fertilizers in just one month, compared to 4-6 months from traditional composting. This approach addressed two challenges simultaneously: managing agricultural waste and enhancing farm productivity with affordable fertilisers.

Multiple companies in the region utilised self-harvesting pupae systems. A system where neither labour nor sieve equipment are required to separate pupae from the larvae, thus minimising cost. Using the insect's natural behaviour to one's advantage is reminiscent of dairy farmers encouraging their cows to walk to the grass, rather than bring the grass to them. Simple agricultural efficiency.

Figure 21: Self harvesting pupae system.

East Africa holds significant potential for scaling BSF farming with replicable, low-cost models of production.

Learning: A BSF farm doesn't necessarily result in crates, robots, and big factories.

To summarise the tour, it is quite clear that there are many different ways to approach the insect industry. Many new models and methods are only in the experimental stage, some simply exist as a thought, yet to be enacted. It makes one wonder how many innovations are being withheld within people's minds.

All these lessons give the biggest learning of all: insect farming has no playbook from which to draw information. The playbook is waiting to be written.

3.3 General Attitudes Towards Business

During the study tour, a range of attitudes and mindsets among industry stakeholders became apparent. While many individuals demonstrated innovation and ambition, several prevalent misconceptions and misaligned approaches pose significant risks to the development of the BSF industry. These attitudes not only hinder individual businesses but also threaten the collective growth of the sector. The examples provided may seem extreme, but they serve to highlight the critical issues we face.

Attitude: "My intellectual property (IP) is the sole reason I will succeed."

Reality: IP is undoubtedly a valuable asset, and protecting it is essential for any business. However, excessive secrecy and a refusal to share knowledge stifle industry-wide progress. A collaborative approach—where knowledge-sharing builds trust and expands the potential market—is more sustainable. The industry's long-term success depends on collective growth. After all, it's far better to share a larger growing pie than to tuck in to a single serve pie-for-one. Furthermore, to target the future commodity market, multiple players need to be in the market to ensure security of supply long-term. This is not a winner-takes-all industry, so collaboration is not just nice to have, it is necessary to the future of the industry.

Attitude: "Once we achieve low-cost supply, it will sell itself."

Reality: While generating consistent and low-cost supply is undoubtedly challenging, the notion that demand will inevitably follow is misguided. There is quite a lot to unpack here, but in a nutshell, there needs to be more focus on the customer and how BSF products solve specific problems, rather than their own. Many of the industry leaders cite motivations such as reducing food waste, improving food security, or financial success, all of which are highly commendable in their own right. However, these goals don't necessarily align with customer motivations. To use a simple example, a chicken farmer will probably have sustainability and food security aspirations but would first like to improve her (FCR) feed conversion ratio and bottom line. Tests must be done with the chicken farmer to improve their FCR and bottom line. The same can be said with corporations' food waste, council's water pollution and arable farmers' crop yield goals, to name a few more examples. Clearly, having a low-cost product is high on the priority list, but successful industries require balanced

development of both supply and demand; failing to prioritise one will lead to unsustainable growth.

Attitude: “Once I gain investment, I can scale the business and solve all the world’s problems.”

Reality: Scaling insect farming is far more complex than many investors and entrepreneurs anticipate. Out of the 35 animal phyla, humans have only commercially farmed one at scale – vertebrates – with limited success elsewhere outside of crustaceans and bees. Farming insects presents entirely new challenges, from understanding insect biology to designing efficient production systems. Investment alone cannot solve these challenges. Success will require time, a commitment to learning and collaboration. The industry must adopt a methodical approach, recognising that rapid scaling without a foundational knowledge base can lead to failure.

Attitude: “Vertical farming insects is the best model.”

Reality: Media portrayals often focus on futuristic vertical farms, with robotic systems and conveyor belts managing insect crates that have been stacked high and wide. These models may look impressive, but they are not the only—or necessarily the best—way to produce insects. Innovative alternatives are emerging across the globe. For example, Insect Engineers in the Netherlands repurpose mushroom racks for stacked insect beds, while Entoprot in Finland is experimenting with bioreactor technology akin to a giant insect cement mixer. In Tanzania, Chanzi employs low-tech larvae pits in polytunnels. The diversity of approaches highlights the importance of agility in production models. The industry is still in its infancy, and it remains unclear which systems will prove most effective in different contexts.

Attitude: “I must grow fast, otherwise I will be left behind”

Reality: Unfortunately, we in the industry right now are minnows. The global soybean and fishmeal production is 420m and 6m tonnes per annum, respectively. Meanwhile, 1.5bn tonnes of human food is wasted every year. The largest insect factory globally, Innovafeed in France, claims a pathetic capacity of 100,000 tonnes of insect meal – that’s 0.02% of the total soy production, which also happens to be growing far more quickly than the insect industry in absolute growth terms. The aim is to produce a protein commodity, which requires a mature industry, built upon solid foundations, in a perfect competition marketplace, where supply and demand interact at an equilibrium. As it stands, the dominant protein commodity is the soybean, with huge volumes at play. Within the nascent insect farming world, there is no competitive tension with each other. The sooner that we all realise that we’re not competing with each other, the sooner we can collaborate and grow together.

Learning from High-Profile Failures

The fragility of these attitudes is exemplified by high-profile casualties in the BSF sector. Agriprotein in South Africa, Enterra in Canada, and Ÿnsect in France were all early adopters of insect farming practices, had large, centralised factories, and paved the way for many entrepreneurs. They also revealed the industry's vulnerabilities. Over-reliance on any single production model; excessive scaling without foundational knowledge; or failing to balance supply with demand can lead to significant setbacks. These examples serve as a cautionary tale for current and future stakeholders, emphasizing the need for realistic expectations, collaboration, and adaptability.

The misguided attitudes and approaches identified to be common in the BSF industry underscore the critical need for a grounded, data-driven understanding of what truly drives business: profitability.

3.4 The Mathematics

This brings me onto the prevailing question for the Black Soldier Fly (BSF) industry: whether it can shift from being driven by sustainability narratives and corporate ESG targets to becoming a commercially profitable sector. The answer lies in understanding the economics of insect farming, as detailed in Michael Badeski's report, "*Investment Insights for the Insect Industry.*" The author is ex co-founder of Singapore-based insect start-up INSEACT and the aim of his report is to share insider insights that were previously confidential. Central to Badeski's analysis is the Blended Substitute Value Ratio (BSVR), a metric he devised to benchmark the profitability of insect businesses, which was formulated in protest to the various vanity metrics commonly used in the industry, generally centred around tonnage and yield.

Understanding the BSVR

Badeski's Blended Substitute Value Ratio seems both simple and obvious yet is underutilised across the industry. It is calculated as follows:

BSVR = total revenue from all products / total production costs

The eagle-eyed reader would recognise this formula simply as gross profit. However, this is something that, incredulously, is ignored in the industry.

To understand the output of this calculation, a BSVR greater than 1 indicates that a BSF operation is economically viable, with revenues exceeding the costs of production. This metric integrates all outputs of a BSF facility - protein, oil, frass, and feedstock gate-fee - and compares them against total costs, including feedstock procurement, labour, energy, and depreciation of capital investments.

Component	Value (USD)	Description
Defatted protein revenue	$1,800	Revenue from selling 1 tonne of defatted insect protein.
Oil revenue	$450	Revenue from selling 0.3 tonnes of insect oil (generated alongside 1 tonne of defatted protein).
Frass revenue	$150	Revenue from selling 12 tonnes of frass as fertiliser (generated alongside 1 tonne of defatted protein).
Total revenue	**$2,400**	**Sum of all revenue streams from outputs.**
Feedstock cost	$600	Cost of obtaining and processing feedstock inputs.
Labour cost	$400	Labour expenses for operations.
Energy cost	$300	Energy expenses for production processes.
Depreciation and capital cost	$400	Depreciation of equipment and facility costs.
Total production cost	**$1,700**	**Sum of all costs associated with production.**
BSVR	**1.41**	**Calculated as Total Revenue / Total Production Cost.**

Table 1: BSVR of an optimised BSF operation highlights the profitability potential of the industry.

For example, Badeski's analysis of a model facility producing 1 metric tonne (mt) of defatted protein (with the associated 0.3mt of oil, and 12mt of frass by-products) showed total revenues of $2,400/mt of output, at replacement commodity market prices, against total costs of $1,700/mt. This resulted in a BSVR of 1.41, meaning that for every $1 spent, the facility generated $1.41 in revenue. Remember that Badeski's outputs are based on prudent costing and commodity value prices. It does not utilise any value-added markets, future markets such as carbon or industry development that drives down costs over time. Such a positive BSVR from the inception of the industry demonstrates that, under optimal conditions, BSF farming can achieve profitability. And comfortably.

However, the reality is more complex. Regulatory restrictions, inconsistent demand, high upfront costs, and flawed attitudes and approaches as explained in the previous section create significant barriers, making the mathematics less favourable and, in a lot of cases, negative. The next chapter will zoom into these constraints using the UK as a case study, exploring how they undermine the profitability of BSF farming, then identifying pathways to address them.

CHAPTER 4: THE UK PROBLEM

The UK presents a unique set of challenges for the BSF industry. While analysing the unit economics have demonstrated that BSF farming can be profitable, the UK's regulatory, economic, and infrastructural environments undermine this opportunity. This chapter explores the critical barriers that affect the feasibility and profitability of BSF farming in the UK, illustrating how these constraints disrupt the promising mathematics outlined in the previous chapter.

4.1 Barriers To Adoption

4.1.1 Regulatory Barriers

Feed £/t	£90
FCR (wet - wet)	5
Feed cost (wet larvae)	£450
Dry Matter	30%
Protein content	60%
Feed cost (protein meal)	£2,500

Table 2: UK regulations can make the feedstock very costly.

In the UK, insects may only be reared on approved substrates, which generally exclude low-cost organic waste streams, such as food waste or animal by-products. Instead, BSF farmers must rely on expensive pre-consumer food waste, dramatically increasing production costs. Not only does this restriction diminish one of the key advantages of BSF farming: the ability to valorise waste streams that would otherwise go to landfills. But it significantly increases the cost. One tonne of defatted insect protein would cost anywhere between £1,000 and £2,500 on feedstock alone. Quite the price for a waste product and makes soy protein look very enticing indeed.

Insects are currently identified as livestock, so cannot technically be fed un-approved feedstocks, even if the BSF is solely used as a waste processing agent. However, we have a special exemption for feeding ABP's to maggots used for fishing bait. Further clarification is needed on this if we are to give ourselves the tools to approach food waste problems in the UK.

On the product side, UK Transmissible Spongiform Encephalopathies (TSE) related laws state processed animal protein (PAP), including insects, can only be used in aquaculture feed, with prohibitions on its use in poultry, pig, ruminants, etc. This limitation significantly narrows the potential customer base and reduces demand for BSF protein. An interesting loophole in the UK legislation currently permits feeding of live insects to livestock, regarding that they are not processed.

Globally, more permissive regulatory environments have allowed the BSF industry to thrive:

- **European Union:** Insect PAP is approved for poultry, pig, and aqua feeds, providing a broader market base.
- **Africa:** Countries like Kenya and South Africa have fewer restrictions on feedstock usage, enabling BSF farmers to use organic waste streams effectively. These regions also have growing markets for frass as a soil improver.

- **North America:** The USA and Canada have adopted a more flexible approach, permitting a wider variety of feedstock inputs and encouraging innovation in product applications.

The UK's regulatory stance contrasts sharply with these regions, leaving its industry at a competitive disadvantage.

More information of UK regulations can be found in appendix 2.

4.1.2 Economic Constraints

A banker, a politician, and an entrepreneur are in a bar. The entrepreneur pitches his revolutionary BSF business to the banker. She sips her beer and says, "I'll invest, if the politician makes it more profitable for me by changing the regulations." The entrepreneur turns to the politician, who shrugs. "I've not got time for this, come back when the market's more developed." The entrepreneur slams his pint down. "Without the investment, the opportunity will fly by."

In contrast to the sustainability story, which resonates with ESG investors, there isn't currently a narrative for escaping the cycle demonstrated in the story above. It's not easy in a nascent industry. Without an economic reason to invest and with significant capital and operating costs, only ESG investors with a high-risk appetite, typically venture capitalists, will invest in such an industry.

As previously stated, the regulation in the UK is a significant barrier to adoption. Since the EU has approved insect PAP, investment in France and the Netherlands has skyrocketed, leading to even more public funding.

Funding (USD m)	Country
954	France
143	USA
126	Netherlands
80	Canada
70	South Africa
38	Singapore
36	UK
33	Vietnam
28	Israel
23	Australia
19	Spain
15	Chile
8	Ireland
8	Germany
6	Bulgaria
5	Lithuania
3	India
3	Estonia
3	Sweden
3	Czech Republic
1	Italy

Table 3: Global private fund-raising of BSF companies by country.

4.1.3 Supply Chain Development

BSF rearing is commercially prohibitive due to high input costs, expensive technology, and under-developed demand streams, which are over-reliant on low market dump prices. Building a stronger end-to-end supply chain will enable BSFL rearing. The BSF model can mimic the successful broiler industry of breeders, feed suppliers, broiler growers and large-scale processors to develop the industry.

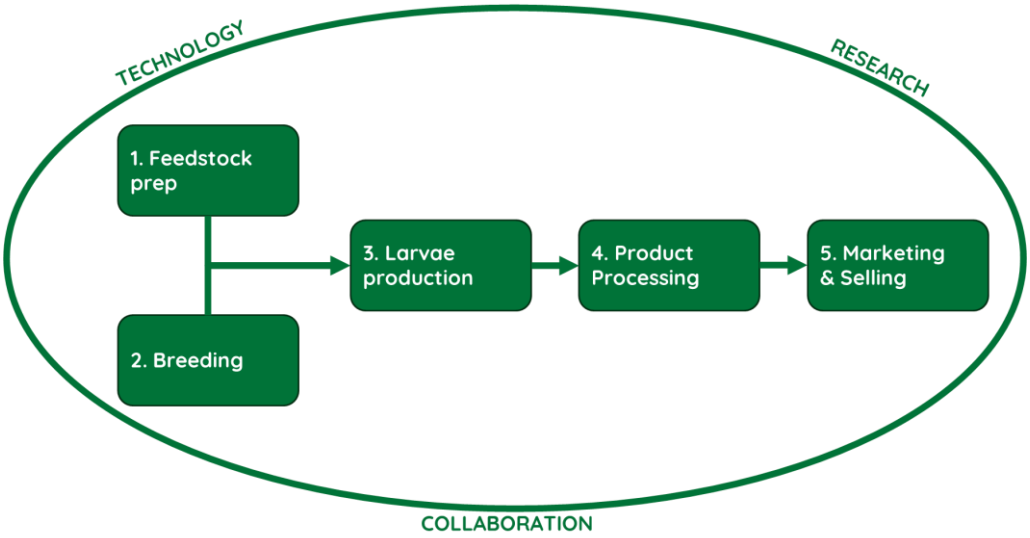

Figure 23: A vision for the future? How the BSF industry could take shape.

Input Infrastructure

Breeding consistent, high-quality BSF neonates, which are a critical input for scaling operations, is technically challenging. Many UK breeders cannot currently produce at a low enough cost to enable large scale adoption of larvae growing. It is possible to import from more affordable foreign suppliers, but quality is inconsistent in transit, where temperature, humidity, and - most importantly - time present a tricky challenge.

For feedstock input, Zero Waste Scotland have mapped the organic waste streams for Scotland, yet the understanding of sources is limited in England. Instead, the upcoming Separation of Waste (England) Regulations 2024, mandating separate food waste collection, would increase feedstock availability for BSF farming from March 2025. This regulatory change could lower feedstock costs and improve access to organic waste streams, providing a much-needed boost. However, as explained previously, low value and low-cost substrates are regulated against, limiting their use.

Technology and Science

The UK is a global leader in scientific research, with strong academic expertise in entomology and bioconversion. However, producer adoption of advanced technology in BSF farming lags behind due to high costs of bespoke equipment.

Product Processing

Processing BSF-derived products, such as frass, oil, and protein meal, into market-ready outputs is another underdeveloped area in the UK. Developing regional processing hubs could address this issue, ensuring cost-effective conversion of raw BSF outputs into value-added products. This would be best enabled by producers forming a co-op model, selling volume to one larger processor, rather than doing it themselves.

Output Offtake and Market Development

- Niche Markets: There is growing interest in BSF frass as a soil enhancer, insect oil for specialty feeds, biodiesel and cosmetics, or chitin for pharmaceuticals. However, these markets remain small and/or poorly developed. Due to a lack of producers, a co-op model of shared processing and marketing isn't currently viable.
- Distributors: A lack of established distributors for BSF products limits market reach. The UK needs intermediaries capable of connecting BSF producers with retailers, farms, and end-users.
- Customer awareness: The product is currently at the very start of the product adoption curve (figure 24), meaning finding the customers willing to take on risk is challenging.

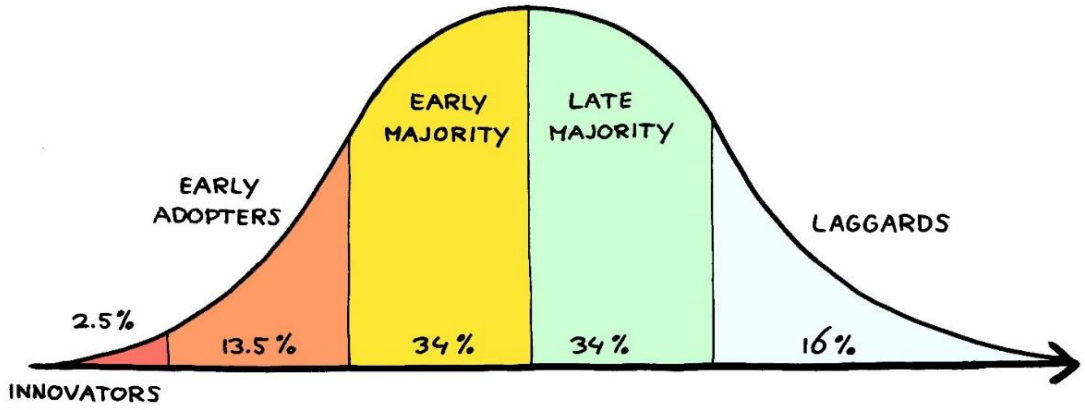

Figure 24: The 5 stages of technology adoption indicates that consumer acceptance takes time.

4.2 Case study: Vertical Farming vs Anaerobic Digestion (AD)

The economic constraints facing BSF farming can be better understood through a comparison with two similar sectors: vertical farming and AD. These industries have experienced starkly different fortunes in the UK and the world, providing valuable insights for the BSF industry.

Vertical Farming (VF):

VF - much like BSF farming - requires substantial CAPEX for automated systems, controlled environments, and advanced technology. In the UK, VF has struggled to scale up due to high energy costs and low food prices. The government has not stepped in with a subsidy scheme to support the adoption. Despite initial enthusiasm and investment, many VF businesses have faced financial difficulties, highlighting the risks of over-reliance on automation and high-tech solutions without robust market demand.

Anaerobic Digestion (AD):

By contrast, anaerobic digestion has thrived in the UK, largely due to strong government support in the form of subsidies, feed-in tariffs, and renewable

energy incentives. AD plants benefit from a clear revenue model—processing waste to generate biogas and sellable by-products. This has enabled supply chains and demand to develop over time. It's commonly said that without the support of European incentives, AD would never have prospered, and this combination of regulatory clarity and financial incentives has allowed AD to succeed where vertical farming has faltered.

It is important for the BSF industry to learn from the AD story and exactly why it was that European governments poured so much faith into AD. The catalyst was public pressure towards environmental issues, and the diminishing availability of landfill sites. Additionally, the oil crisis in the 1970's underscored the need for European energy security, for which fossilised sources were limited. Both of these ideas align with real world, public problems that policy makers of the day needed solutions for.

If we were to look at the issues facing us today - food security, waste, and net-zero ambitions - these can all be addressed through BSF farming, and this is the angle that we should take towards influencing governments for support.

4.3 The UK Economics

To return to Badeski's BSVR report from chapter 3.4, and given the market restrictions identified in this chapter, it is reasonable to conclude that the principal industry objective – to replace soy protein - is not possible today. This is shown in the updated BSVR table giving today's soy replacement aspirations a paltry 0.19, compared to the lofty and profitable 1.41 under ideal conditions.

Component	Value under optimal conditions (USD)	Value under UK conditions (USD)	Description
Defatted protein revenue	$1,800	$0	Revenue from selling 1 tonne of defatted insect protein.
Oil revenue	$450	$450	Revenue from selling 0.3 tonnes of insect oil (generated alongside 1 tonne of defatted protein).
Frass revenue	$150	$150	Revenue from selling 12 tonnes of frass as fertiliser (generated alongside 1 tonne of defatted protein).
Total revenue	**$2,400**	**$600**	**Sum of all revenue streams from outputs.**
Feedstock cost	$600	$2,000	Cost of obtaining and processing feedstock inputs.
Labour cost	$400	$400	Labour expenses for operations.
Energy cost	$300	$300	Energy expenses for production processes.
Depreciation and capital cost	$400	$400	Depreciation of equipment and facility costs.
Total production cost	**$1,700**	**$3,100**	**Sum of all costs associated with production.**
BSVR	**1.41**	**0.19**	**Calculated as Total Revenue / Total Production Cost.**

Table 4: An updated BSVR under UK conditions.

This table only shows the impact from the current regulation in the UK, which increases the feedstock cost and restricts the ability to sell as a livestock feed. Whilst pet food markets can be targeted, customer awareness and demand for insect-based pet foods is low, so it is not a solution for scaling the industry. The production issues observed at large producers have resulted in spreading vast overheads over lower production volumes than forecasted. It is not only regulations that limit the opportunity, but also the lack of knowledge and under-

optimised practices that impact the efficiency and, hence, the economic viability of BSF farming.

The profitability of BSF farming under UK conditions paints a bleak picture.

However, the critical point is that whilst the economics stack up when it is under optimal conditions; it is the barriers in place that are shackling the industry.

CHAPTER 5: SUGGESTIONS FOR SUCCESSFUL MODELS OF PRODUCTION IN THE UK

5.1 Waste Processing

Council Food Waste

The Separation of Waste (England) Regulations 2024, which mandate separate food waste collection, present an opportunity to integrate BSF farming into municipal waste management systems. By processing food waste that would otherwise be sent to landfills, councils could reduce landfill taxes and cut methane emissions at a fraction of the cost of installing an AD plant. BSF businesses could adopt an approach similar to Proteen in East Africa and incorporate the larvae as part of the frass. This model generates revenue with gate fees and frass sales because feedstock regulations disallow the use of the larvae as a feed source.

Current incentives for food waste processing point to AD, as the UK government has invested so heavily over the last 30 years and the technology has proven itself to some degree. However, it's noticeable that the Western Cape has launched a similar zero organic waste-to-landfill law and, with more of a blank canvas, have opted to focus attention on BSF. The big question here is: what does it better, AD or insects?

Manures In NVZ areas

The UK's nitrate-vulnerable zones (NVZs) face strict restrictions on manure application to land. BSF farming could provide a solution by transforming surplus manure into valuable products: reducing environmental runoff and generating additional revenue for farmers. Compared to chicken manure, frass is drier and releases nutrients more slowly, so it is less prone to causing nitrate leaching. The approach is similar to that seen in 5.1.1 relying on revenues from gate fees and frass. In the Netherlands, due to excessive nitrification, farmers are now having to pay to sell their manure. Will we see this happen in the UK?

5.2 Hub and spoke

A hub-and-spoke model involves a centralised breeding facility (the hub) supplying BSFL to satellite rearing operations (the spokes). Further processing can be controlled by the hub operation; however significant scale is required to make this process economic. This model was encountered across a varying degree of sizes, ranging from 25t per day seen at Feed4Future, to shipping container models. Due to the short but frequent input and output deliveries, local mapping of waste streams and offtakers is required and developing supply alongside high value niche demand is required.

The processing of insects can be a costly step, due to the smaller scale. The feeding of live larvae eliminates the need for this step and when poultry will happily consume this lower cost product. Furthermore, this form of enrichment of poultry and/or pig feeds avoids the PAP regulations, as it involves live insects, rather than processed. Research suggests there are both welfare and nutritional benefits for the chickens when fed live BSFL. Transporting live insects is expensive, due to the weight difference, so offtakers must be nearby to make it cost effective.

5.3 Centralised

A centralised model involves a large-scale BSF facility capable of processing substantial quantities of feedstock and producing high volumes of protein and fertiliser. This model is suited to regions with consistent feedstock supply and established markets for BSF products. This model is high risk due to high capital and operating costs, but if you can hit the production targets, have buyers for the products lined up. and keep the costs down, then scale opens up endless possibility and the rewards are there for the taking. As mentioned in this report, right now it seems more important to be agile than efficient in this industry, and to wait for the regulations to change to reduce risk in the approach.

5.4 Ring fenced circular economy

A ring-fenced circular economy model involves integrating BSF farming into a closed-loop agricultural or industrial system, where waste from one process serves as input for another. Ololo Lodge in Kenya exemplified this approach with its high value tourism business benefitting from a circular economy farm. This is an opportunity for market gardeners or farm shops to capture the interests of their customers in the UK.

Figure 25: Ololo Farm's circular economy, Kenya.

CHAPTER 6: CREATING A SUCCESSFUL INDUSTRY

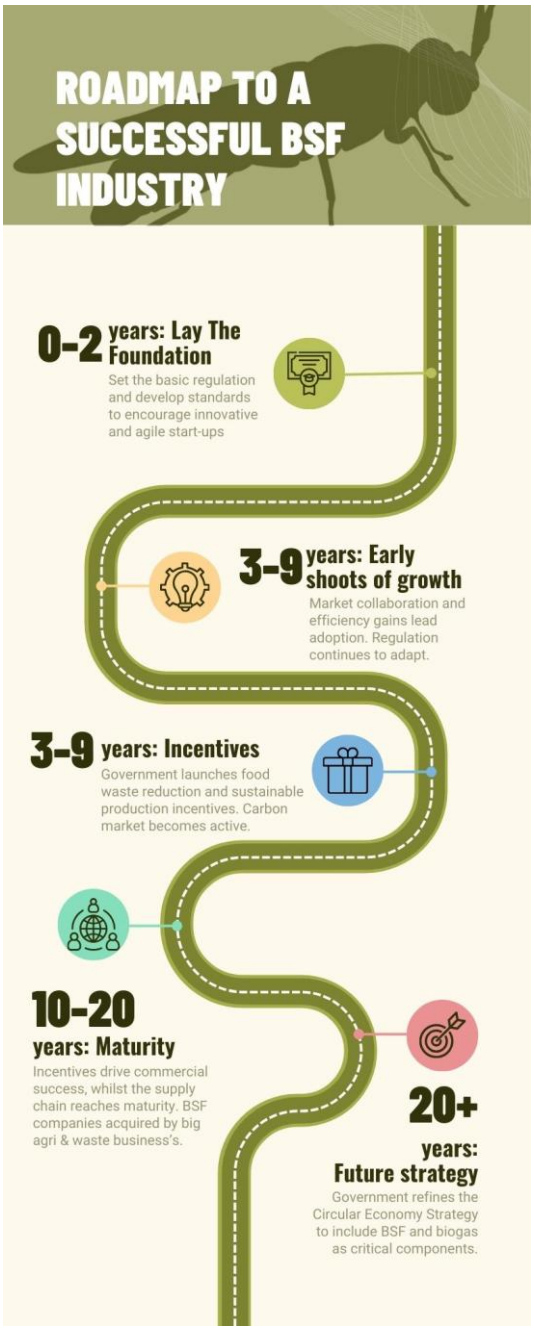

Figure 26: Author's own prediction of a 20-year industry roadmap.

6.1 A Roadmap To Success

It is in our collective interests to ensure the success of this industry, as it offers a means to help the UK achieve critical net zero; food waste reduction; and food security goals. Instead of individual businesses working in silos and attempting to build the industry independently, a collaborative, well-defined, 20-year roadmap involving contributions from all stakeholders provides the strongest foundation and the highest likelihood of long-term success. Such a coordinated approach is essential to overcome the challenges facing the industry and to fully unlock its potential.

Image 26 shows what the 20-year roadmap might look like. The process begins with fundamental regulatory reforms and an emphasis on fostering collaboration among start-ups during the early stages of the industry's development. The medium-term highlights the importance of synchronised growth in both supply and demand, accompanied by continued regulatory adaptation and emerging government support through incentives, grants, and subsidies. If the industry follows this trajectory, long-term maturation becomes an achievable reality, enabling the seamless integration of BSF farming into traditional agricultural systems.

A more detailed roadmap can be found in Appendix 1, which outlines each phase in greater detail and serves as a guide for stakeholders aiming to contribute effectively to the industry's success.

6.2 Risks

This report cannot present a 20-year roadmap, without effectively analysing the risks. These risks are shown in table x.

Risk	Description	Impact	Likelihood	Timescale	Mitigation
Regulatory inertia	Regulatory reform could be delayed, watered down, or not happen at all.	**High: The UK risks falling behind other countries in BSF industry development.**	**Medium**	Short to Medium term	Engage policymakers, develop standards and align industry goals with government priorities (e.g., net zero, waste reduction, food security).
Market development risk	Niche markets may not grow quickly enough.	**Low: Under-developed demand for niche products may force BSF farmers to compete on commodity pricing.**	**Medium**	Short to Medium term	Diversify revenue streams and educate consumers to grow demand for niche products. The presence of product aggregators and marketing desks would help.
Funding shortfalls	The industry must prove its value to access continued funding. This includes agricultural benefit, positive public good impact, and commercial profitability.	**Medium: Slower innovation and scaling, reducing competitiveness.**	**Medium**	Short to Medium term	Demonstrate clear ROI through pilot projects and attract ESG-focused investors. Early profitability reduces reliance on funding.
Investors spooked	Poor BSF practices lead to high-profile failures.	**Medium: Investment in the industry could decline, similar to that seen in vertical farming.**	**Medium**	Short term	Early stage collaboration to learn from each other's mistakes. Remain focused on "why".
Insect welfare	Unethical insect welfare practices invite scrutiny and undermines industry reputation.	**High: Loss of consumer and investor trust.**	**Low**	All	Develop collaborative industry standards and transparent certification processes.
Lab-grown meat	Growth of lab-grown meat reduces demand for agricultural inputs.	**Unknown: Demand levels impacted by lab-grown meats are uncertain.**	**Low**	Long term	BSF for waste processing immune to this risk.
Alternative proteins	Development of alternative proteins (non-insect) may surpass BSF in efficiency, cost, or scalability.	**Medium: Insect-based solutions could be sidelined, especially if competitors focus solely on nutrition.**	**Low**	Medium to Long term	Position BSF farming as a multi-functional solution offering waste management, animal nutrition, and soil health.
BSF imports	Imports from countries with favourable conditions outcompete UK production.	**Low: UK producers struggle to compete on cost and quality.**	**Low**	Long term	Focus on input-led / circular models (e.g., waste processing), and leverage UK sustainability branding. There will still be opportunites for managing UK demand.
Genetic development failures	Cold-resistant strains impact biosecurity and industry reputation.	**High: Potential for invasive species and regulatory tightening.**	**Low**	Long term	Adopt strict genetic protocols and collaborate on biosecurity measures.
Feedstock supply	Increased competition for feedstock reduces availability and increases costs.	**Low: Feedstock supply could be the limiting factor, leading to higher production costs.**	**High**	Medium to Long term	Map feedstock sources, develop partnerships, and explore alternative inputs.

Table 5: BSF industry risks.

6.3 The Rest Of The World

While this report primarily focuses on the UK as a case study, the lessons learned and challenges identified can be applied globally, highlighting opportunities to create a cohesive and successful BSF industry on an international scale.

Comparative Advantage

Tropical countries offer natural comparative advantages for BSF farming. With low labour and energy costs these regions have the potential to supply the world with commoditised BSF products like defatted protein meal and insect oil, meeting the needs of aquaculture and livestock industries at competitive prices. However, aligning with global markets and import regulations is key.

On the other hand, high-tech economies, like in Western Europe, could drive innovation in automation, genetics, and production technology. This approach mirrors the way different regions contribute to other agricultural industries, such as soybean production and processing.

Collaboration across borders, such as shared technology and trade agreements, can strengthen supply chains. For instance, a tropical country producing high volumes of BSF meal could export to Europe, where processors turn it into tailored products for niche markets. This global interconnectedness could accelerate BSF adoption on a scale not feasible in isolated markets.

Waste Management as a Universal Opportunity

The BSF industry's ability to valorise waste streams into high-value products is relevant across geographies. Urban centres with large volumes of organic waste could utilise BSF farms as decentralised waste management hubs. These farms not only reduce landfill usage but also create localised opportunities for fertiliser and protein production, fostering circular economies in densely populated regions.

Additionally, countries with stricter landfill regulations could integrate BSF farming into broader waste management strategies. Conversely, regions with abundant organic waste and fewer restrictions, such as that seen in East Africa, can capitalise on the availability of low-cost feedstock to drive growth.

Building a Resilient Global Industry

A cohesive global BSF industry requires balancing local comparative advantages with global goals. By adopting best practices from regions like the UK, where regulatory challenges have forced innovation, and combining them with tropical efficiency or European technological leadership, the BSF sector can evolve into a resilient and scalable solution to global challenges.

Ultimately, the UK's case study is a starting point. By understanding the unique strengths and challenges of different regions, countries can collaborate to build a

thriving global BSF industry that addresses protein demands, waste reduction, and soil health on a truly international scale.

CHAPTER 7: CONCLUSIONS

- **BSF farming is profitable:** Growth rate; reproductivity; ability to consume low-grade wet feed; and not being classified as a pest species; are all characteristics that make BSF farming a profitable and scalable option to address key challenges, such as net-zero goals, food security and reducing food waste.

- **Multi-Functionality:** BSF farming offers more than just protein; its ability to address waste management; produce plant and animal nutrition; and provide circular economy solutions makes it a unique and multifaceted opportunity.

- **Current limitations risks leaving the UK behind the global BSF industry:**
    - Regulation is the biggest barrier and is the primary cause for the symptoms identified below.
    - High production costs is the next largest barrier to adoption.
    - A lack of cohesive supply chains hinders the development.
    - The requirement to develop demand is underappreciated by the industry, unlike a widespread appreciation for the first three challenges listed.

- **Prevailing industry attitudes are limiting industry potential**: Over-reliance on IP secrecy and assumptions that supply will automatically generate demand, are detrimental to industry growth. Collaboration, demand creation, and agility are essential mindsets for overcoming these challenges.

- **We are just at the beginning:** The sheer variety of BSF farming models and approaches found globally suggests that there is no playbook, but we are writing it.

CHAPTER 8: RECOMMENDATIONS

- **Regulatory Reforms:**
  - Expand approved feedstocks to include post-consumer food waste and manures, under strict safety protocols and a science-led approach.
  - Align the UK's regulatory framework with the EU to allow insect PAP in poultry and pig feeds.
  - Reclassify definition of livestock with regards to insects.

- **Collaboration and Standards:** INBIA (Insect Bioconversion Association) was set-up in 2024 in the UK to share best practices, set production and welfare standards, and advocate collectively for regulatory changes. This must progress with a supply chain strategy to map feedstock availability, and a science strategy to identify the biggest gaps for research, in order to accelerate the industry.

- **Specialise:** Specialise with centralised breeding, product processing, product aggregation, and sales efforts, with collaboration strong across the entire supply chain.

- **Build Agility into Business Models:** Encourage BSF start-ups to experiment with diverse production and revenue models, such as hub-and-spoke systems or input-led waste management models. Avoid capital intensive, centralised production in the short-medium term.

- **Economic focus:** Utilise all revenue streams available to maximise the BSVR – thus, the profitability – of the venture.

- **Political strategy:** Align the industry with political priorities to enable government subsidies or tax incentives to offset the high initial costs of BSF production and de-risk investment in the sector.

- **Research and Innovation:** Focus first on safety and acceptance of insect production to guide regulation. Then focus on long term R&D by both reducing cost through genetic development, automation, and production techniques, and by increasing revenue potential through product development innovation. Finally, it is worthwhile to investigate the safety, science, and business model effectiveness of processing of manures and/or municipal food wastes to address organic waste problems.

CHAPTER 9: AFTER MY STUDY TOUR

Business - Fly2Feed

After all I've seen and learned on this journey, I'm convinced that the BSF industry is where I'm meant to be, despite it being a bit like trying to fly a plane whilst building it. My business, Fly2Feed, is small, and the industry is tough. But the potential rewards and the chance to make a meaningful impact give me a good reason to get out of bed early every day.

Since returning, I have continued my work producing BSFL, feeding them to broiler chickens, and have had some fantastic results. On enriching the broilers' diet with a small inclusion of live larvae, the chickens have made spectacular live weight gains. In an industry where marginal gains drive profits, what I've observed is gold dust and worth a lot of money. This is not to mention the welfare benefits observed in the behaviours of the chickens. I have secured and started an Innovate UK project testing the development of a hub and spoke production model, whereby breeding and feedstock supply is centralised and BSFL production is located at broiler farms within a short distance.

As for the future of Fly2Feed, I feel spoilt for choice. Should I go big on waste processing, or stick with poultry feed supplements? The options are equally enticing, but like Charlie Munger says, "*Success means being very patient, but to strike with aggression when it's time*." One thing is certain—I'm here to build something that lasts.

Making Some Cash

In these early days, I quickly realised that passion alone doesn't pay the bills. At one point, I even toyed with the idea of taking on a local fish farm that seemed to be like a guaranteed cash cow. But it all smelt a little too fishy for me. So, I decided to capitalise on my knowledge and take on BSF consulting jobs. It turns out that being obsessed with insects for years actually has some market value!

Being a Thought Leader

Sharing my adventures online has earned me a spot as a minor celebrity in the insect farming world. A niche category at best, but I'll take it. The feedback has been incredible, and the connections I've made have opened doors I didn't know existed. A big learning from my travels has been how, what I believe to be wrong, attitudes in the industry could be shaping the future. So, I am planning to launch a podcast to expand my reach, be the point of reference in this industry, and, most importantly, give the right people a stage to express their views on how to drive the industry forward.

But I don't just want to be in the conversation—I want to lead it. The BSF industry needs direction, and I intend to be at the forefront of shaping its future. Whether

it's through research, consulting, or scaling Fly2Feed, I'm determined to set the standard for what successful insect farming looks like.

Personal Life

This journey hasn't just changed my professional life—it's flipped my personal life on its head too. I left the UK with Katy, my girlfriend, and returned with Katy, my fiancée, thanks to an altitude-induced splurge of courage that led to a rather spontaneous proposal at the top of Mount Kilimanjaro. I should add that I had wanted to ask her for a while. I just hadn't planned where and when. Since then, we've renovated a tired house into something that doesn't look like a BSF farm, and now we're preparing for our next big project: parenthood. Our first child is due in April 2025, which has added a little bit of urgency to getting this report finished.

Before I started my Nuffield, I was told, "There's never a good time to do it." And they weren't wrong. Between the proposal, the house renovations, the pregnancy, travels, running a business, and trying to make ends meet, these past 18 months have resulted in a clumsy lesson in juggling stress and responsibility. But honestly, I wouldn't have it any other way. It's been the perfect (if slightly chaotic) time.

Looking Ahead

Fly2Feed is still a work in progress, much like myself. The BSF industry is full of challenges, but it's also brimming with opportunity. My travels have reinforced my belief that this tiny insect can solve some noticeably big problems. So, while I don't have all the answers yet, I'm committed to staying in the game, working hard, and maybe even having a bit of fun along the way.

I see myself as more than just a business owner—I'm here to be a driving force in this industry. The BSF sector isn't going to build itself, and those who are willing to push the boundaries are the ones who will shape its future. I want to be one of them. Whether it's by pioneering innovative business models, championing regulatory reform, or making sure that insect farming is both profitable and scalable, I plan to be at the centre of it all. The real work starts now.

CHAPTER 10: ACKNOWLEDGEMENT AND THANKS

Thanks to all of my hosts on my journey and to those who made the visits happen, to the inspirational leaders, doers, and thinkers—whatever the motive—because there are lots.

For those who have supported me: Ed Barnston as my Nuffield mentor, the Nuffield interview panel for seeing something in me, and the 2024 UK cohort, who I now count among some of my closest friends.

For those who have not supported me: To the person who, when I asked for advice, told me to "join an established business because you cannot do it from a small scale"—I think about you every day. To the US bus driver who saw Katy on crutches and thought, “You know what this situation needs? A 2x extra baggage charge.” To the fine folks at Calgary council for their impeccable timing in impounding our rental vehicle just two hours before our flight to Europe.

To all the lucky recipients of my wallet, earphones, three baseball caps, and sunglasses that I managed to misplace across four continents—enjoy them. To Nat Hepburn, my personal international courier service, for miraculously retrieving my wallet from Rwanda, proving that at least one of my lost possessions was willing to come back to me.

To my family for tolerating my often mad-scientist methods, giving me the space to test my ideas, and providing the inspiration I thrive on. Particularly my parents—one of whom is also a Nuffield Scholar. I wouldn’t have become a Nuffield Scholar myself without them.

To Katy—for being my biggest cheerleader, enduring my visits (let’s be honest, my Nuffield wasn’t exactly the glamorous one compared to those studying fine cider or high-end beef), and for happily hosting our first baby for the past eight months. I can’t wait to share with you the joys and challenges on the road ahead.

Finally, a very heartfelt thanks go to my sponsors, Alan and Anne Beckett. It is with great sadness that Alan passed away just three months after awarding me this scholarship. I was fortunate enough to meet him once, at his farm shop in Worcestershire, and even in that brief encounter, his wit and wisdom were clear. I hope this report fulfils your expectations.

Figure 27: Alan Beckett.

REFERENCES

Barclays Food Revolution: https://www.ib.barclays/content/dam/barclaysmicrosites/ibpublic/documents/our-insights/FoodWaste/Leaflet%20Food%20Revolution.pdf

Michael Badeski - Investment Insights For The Insect Industry: https://perma.cc/ML9R-QNDW

FERA Science - Supply of data requirement to assess the safety of currently non-permitted waste streams to be used for rearing insects for feed: https://www.food.gov.uk/sites/default/files/media/document/Supply%20of%20data%20requirement%20to%20assess%20the%20safety%20of%20currently%20non-permitted%20waste%20streams%20to%20be%20used%20for%20rearing%20insects%20for%20feed.pdf

THE FUTURE OF FEED - A WWF ROADMAP TO ACCELERATING INSECT PROTEIN IN UK FEEDS: https://www.wwf.org.uk/sites/default/files/2021-06/The_future_of_feed_July_2021.pdf

UK TSE consultation - Livestock feed controls review for England and Wales https://consult.defra.gov.uk/tses-team/review-of-livestock-feed-controls-in-england-and-w/

APPENDICES

Appendix 1: Detailed Roadmap To Industry Success

Phase 1: Foundation (0–2 Years)

Goal: Establish a regulatory and operational framework to remove the largest barriers to adoption and allow start-ups to develop and access finance easier. Markets are under-developed, so large scale operations find it difficult to find valuable offtake agreements.

1. **Regulatory Reform**:
    - Discussions with science and government agencies to update regulations on feedstock use (e.g., allowing the first and safest phase of food waste streams, which is set to be catering waste).
    - Address processed animal protein (PAP) regulations to expand markets beyond aquaculture, including poultry and pig feed.
    - Regulatory change must be a science-led approach to ensure safety concerns are understood, and the risk is minimised. It must be encouraged by aligning process benefits with government priorities, such as waste reduction, net zero and food security aspirations.
2. **Standards Development**:
    - Collaborate with industry stakeholders to create operating standards for BSF farming, including protocols for production, processing, and distribution.
3. **Innovation Funding**:
    - Launch grants and investment incentives for R&D projects focused on improving larvae genetics, feedstock utilisation, automation and developing markets. Aim for this is to build investor confidence and set the foundations for larger projects.
4. **Building Niche Markets**:
    - Develop initial routes to market by targeting high-value, niche sectors such as pet food supplements, organic fertilisers (insect frass), and specialty products like insect oil.
    - If working with agriculture, focus first on the commercial benefit, with sustainability benefits as a bonus, rather than putting sustainability first.
5. **Focus on Agility**:

- Encourage startups to remain small, agile, and collaborative, testing various business models to identify what works best in different contexts.

Phase 2: Growth (3–9 Years)

Goal: Scale production, reduce costs, and align the industry with market demand and ESG-driven investments. Markets have developed somewhat with research developing and formulating niche products that are gaining traction with the customer. Profit margins for small-medium businesses are strong, which is driving sector expansion.

1. **Regulatory Adaptation**:
    - Refine feedstock regulations based on learnings from Phase 1 to include lower-value waste streams, where safe to do so (e.g., municipal food waste, manures).
    - Work toward global harmonisation of BSF-related regulations to enable cross-border trade and investment.
2. **Demand-Driven Production**:
    - Align production with growing demand.
    - Develop partnerships with large-scale buyers in aquaculture, agriculture, and waste management, developing demand from trials to commercial use.
3. **Efficiency Improvements**:
    - Invest in genetic research to improve larvae growth rates, protein yields, feed conversion, and reproductivity.
    - Integrate cost-saving technologies for feedstock pre-processing, automation, and streamlined production models.
4. **Market and Supply Chain Development**:
    - Scale commercial agricultural markets while continuing to target niche applications like biofuels, cosmetics, and pharmaceuticals. BSF farming cannot be profitable without multiple revenue streams.
    - Scientific research focused on high value selling points, such as chitin extraction and purification, and antimicrobial peptides. Products will become available, but not fully adopted during this phase.

- Build out supply chains by mapping waste streams, establishing breeding hubs, and collaborating with processors, retailers, and distributors.

5. **Carbon Market Integration**:
    - Develop methodologies to quantify and certify the carbon reduction benefits of BSF farming, generating carbon credit revenue streams.
6. **Government Incentives**:
    - Lobby for tax credits, subsidies, and grants to accelerate scaling efforts.
    - Propose incentives for adopting BSF farming as part of waste management strategies.
7. **Moderate Scaling**:
    - Define clear operational models and scale production cautiously to avoid oversupply or resource bottlenecks.

Phase 3: Maturity (10–20 Years)

Goal: Achieve a fully established, sustainable, and commercially viable BSF industry integrated into the circular economy. Soy and fishmeal will be steadily phased out and food waste is being recycled. The government looks to a different future of agricultural inputs, embracing a nature-based approach and aiming for greater food security.

1. **Expanded Commercial Markets**:
    - Drive cost reductions through supply chain optimization and economies of scale.
    - Revenue streams for high-value niche markets are established with sufficient demand, thus enabling the sale of bulk proteins and fertilisers for agriculture.
2. **Subsidies for Low-Grade Feedstocks**:
    - Leverage government subsidies to process large volumes of council food waste, manures, and other low-value feedstocks.
3. **Industry Consolidation**:
    - Facilitate acquisitions of successful BSF startups by major agribusinesses and waste management firms to ensure industry stability, investment, and integration.
4. **Circular Economy Strategy**:

- Integrate BSF farming into national waste reduction goals as part of a broader “Circular Economy Strategy.”
- Promote BSF farming and biogas production as critical solutions for recycling organics and achieving better food and energy security.

5. **Global Expansion**:
    - Export expertise, technology, and products to other countries, positioning the UK as a leader in BSF innovation and sustainability.
6. **Ongoing Innovation**:
    - Continue investing in R&D to explore new applications for BSF products and improve operational efficiency.

Critical Success Factors

1. **Collaboration**: Foster partnerships between regulators, researchers, industry stakeholders, and government bodies.
2. **Adaptability**: Stay agile and responsive to changes in market demand, regulations, and technological advancements, identifying and navigating around emerging risks as they occur.
3. **Sustainability**: Align industry goals with global priorities like carbon reduction, food security, and waste management.
4. **Public Awareness**: Educate consumers and businesses on the benefits of BSF products to drive adoption.

Appendix 2: Current UK Regulations

What is allowed in UK:

Farming

- Ento-livestock farmers
- Registered feed businesses (feed hygiene) – for food & feed

Feedstocks

- Pre-consumer food surplus- effectively fruit, vegetable & cereal-based
- Specific animal products, such as dairy & egg surplus (with appropriate treatment), more widely allowed in farmed livestock

Processing

- 7 insect species, including BSF, are allowed, produced through appropriate ABP processing facility

Outputs

- Live insects in monogastric & pet nutrition
- Processed insects in aquaculture & pet food
- Techno-functional, non-food applications

What is not allowed in UK:

Feedstocks

- Any feedstocks containing ABPs or categorized as ABPs – supermarket, hospitality, mixed food manufacturing wastes, municipal food wastes, animal manures cannot be fed to insects that are part of the food supply chain

Processing

- Any species outside of the allowed shortlist of 7 species; any non-compliant with feed hygiene legislation, feed products not derived through ABP processing Methods

Outputs

- Feed: processed in poultry & pig, any ruminant
- Frass: unprocessed frass in select markets (fertilizer)

Grey area:

Insects are classified as a livestock, so cannot technically be fed unapproved feedstocks, even if the BSF is solely used as a waste processing agent. However, we have a special exception for feeding ABP's to maggots used for fishing bait.

ISBN: 978-1-916850-35-4

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
Email: office@nuffieldscholar.org
www.nuffieldscholar.org