CAPITA

fera

Original thinking... applied

Industrial Insect Applications and Services

Insects as Animal Feed and Waste Reduction Solutions



Fera Science Ltd: an overview

- The largest & longest serving provider of agri-food research, services & regulatory advice in the UK with over 100 years of operational pedigree
- Now a limited company, jointly owned by the UK Government & Capita as a private, public joint venture formed in 2015

Our focus is on delivering science for the public good; combined with rapid, emergency response service for food and farming crises

- Working with industry to develop translational science for impact in commercial ventures
- Investing in R&D and analytical capability to provide expertise across the agri-food chain
- UK National Reference Laboratory for food safety across 9 scopes
- Recognized 'Science Organization' by EFSA on Food Safety Regulation and Standards
- Lead partner in UK National Crop Health and Protection Centre (CHAP)
- Chair of UK government Task + Finish Group for Insect Biomass Industry

>100 years of Regulatory, Safety & Expert Support to Government

Food Standards Agency

NATURAL ENGLAND

Department for Environment Food & Rural Affairs

Environment Agency

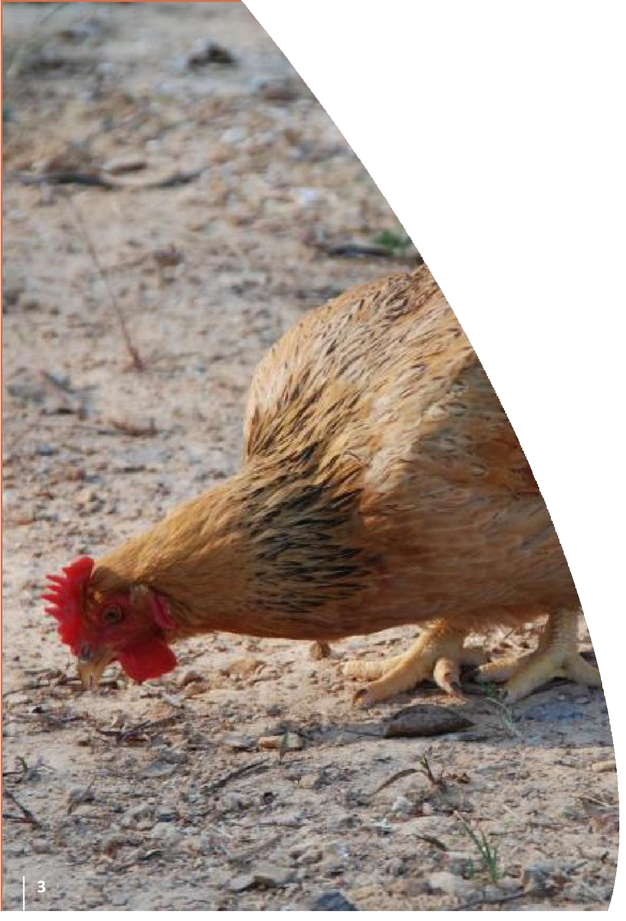
Animal & Plant Health Agency

CHAP

efsa European Food Safety Authority



Fera Science Ltd @ National Agri-Food Innovation Centre in Sand Hutton, Yorkshire

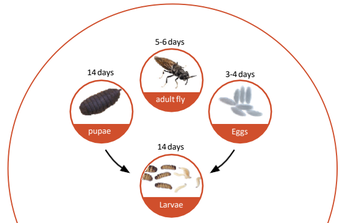


Key drivers for demand of alternative protein sources

- Population growth (estimated 9 billion by 2050)
- Global consumption of meat rising (esp. Asia)
- Growth in aquaculture: fish now represent 16% of global animal protein consumption (World Bank Report 2013)
- Meat (poultry, swine, beef) production expected to double & dairy and fish production to almost triple by 2050 (IFIF)
- Land-use i.e. food crops vs feed crops – environment and food security concerns
- Global feed markets volatile with costs for fishmeal and soyameal increasing
- EU only 25-30% self-sufficient in crop protein - food security and sustainability now critical
- Alternative protein sources for use in animal feed includes insects and algae and uptake increasing subject to regulations

Why insects?

- Insects are highly efficient in the rapid conversion of organic materials into biomass
- They are a natural component of the diets of carnivorous fish and free-range poultry
- Protein digestibility is higher than most vegetable-based proteins
- Land use requirements are lower compared to crop protein
- Higher protein content (30-80% on a dry matter basis) dependant on species and development stage
- Fat content (5-60% d.m.)
- Black soldier fly (BSF) larvae can be reared at scale on organic material
- BSF do not carry human or livestock diseases and are not considered an invasive species risk
- Protein from BSF larvae is proven to be of high quality and suitable for use as a partial replacement of both fishmeal in compound fish & pig feed and soymeal in poultry & pig feed
- Well-balanced highly digestible amino acid profile of BSF larvae is superior to soymeal and more comparable to fishmeal, which typically commands 4-5-fold higher prices as compared to plant proteins in the animal feed sector
- Residue following rearing of BSF larvae on organic material has commercial & environmental value as a fertiliser
- Processing BSF larvae generates valuable additional by-products including chitin, oils and antimicrobials



Black soldier fly Hermetia illucens; Globally preferred insect species for commercial scale animal feed production



Insect species

Primary focus on fly species able to develop on a range of orgainic substrates and agri-manufacturing urban by- products, for example:

Black soldier fly - Hermetia illucens

Mean wt 0.2 g/ larva





House fly - Musca domestica

Mean wt 0.02 g/ larva



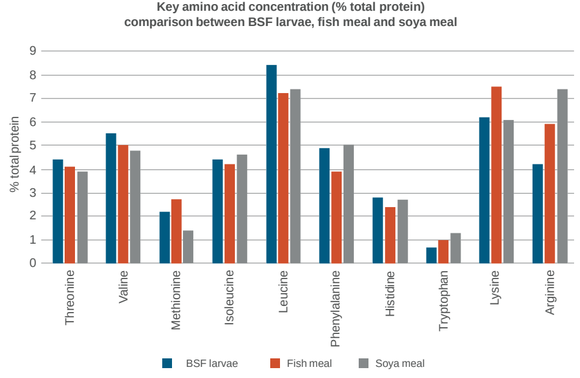


Fera Science Ltd is also exploring research on wider insect species and applications for use in waste reduction and provision of high value products.



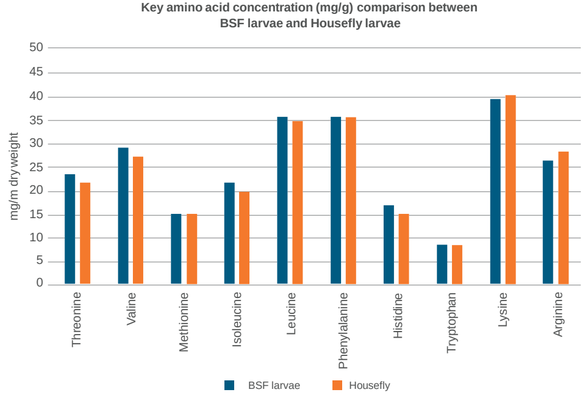
Useful Stats- Quality of insect products

- Nutritional profiles of insect speices determined (protein, lipids, fibre, minerals etc)
- Amino acid profile comparable to fishmeal



BSF and housefly profiles

- Housefly and BSF have similar amino acid profiles
- Fatty acid profiles are variable depending on insect rearing substrate. BSF high in lauric acid



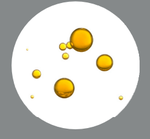
Chitin



Protein meal



Lipids



Fertilizer



Demonstrating the future potential for Insect derived high quality end products. Protein, lipids and fertilizer

Chitin

Benefits	Sample applications
• Sustainable source • Improved wound recovery • Bio-degradable products • Bio-pesticide	• Bio-degradable plastics • Feed bio-additive • Medical dressings • Pharmaceutical products • Waste water purification

Protein meal

Benefits	Sample applications
• Balanced amino acid profile • Very good digestibility > 85% • Highly palatable • Adequate techno-functional properties	• In pet food products, given its nutritional profile and hypoallergenic properties • In fish food for high growth performance, a good feed conversion rate, and a better gut health • In shrimp food as an attractant for better feed intake • In broiler and pig feed for better nutrient digestion and satisfactory productive performances

Lipids

Benefits	Sample applications
• High in lauric acid that has antibacterial and antiviral properties • Easily digestible source of energy • Naturally palatable • Simple integration into products	• In piglet feed for improved feed intake and better gut health • In broiler feed with satisfactory productive performances and overall meat quality • In cosmetics and detergents as an alternative to animal or vegetable fats

Fertilizer

Benefits	Sample applications
• High organic matter (>85%) with nitrogen and minerals • Contains chitin that improves the defense mechanisms of plants • Slow and constant nutrient release over time • Safe and ready to be applied on field	• In soil amendments for farms, gardens, horticulture, and greenhouse • In low fertile soil (acid and sandy soil) with satisfactory results • In crop production for higher yields

Insects for use in animal feed – Market Situation

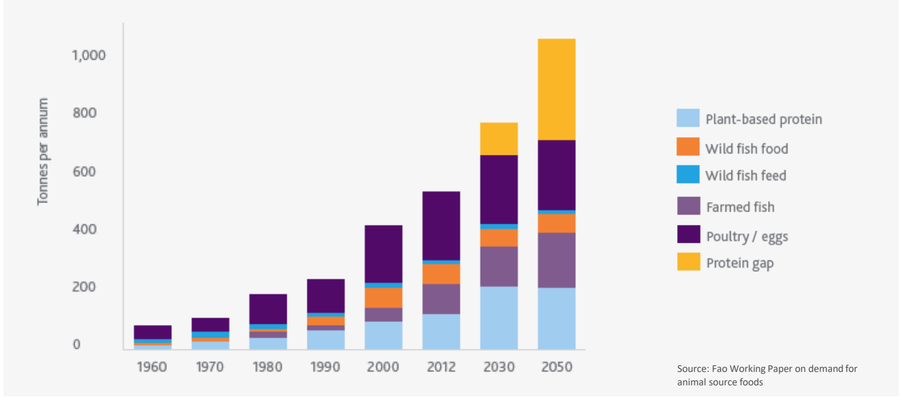
2015 — EU legislation does not allow for insect protein in the food chain

2016 — EU proposes changes to legislation to allow insect protein in feed for aquaculture

2017 — Insect protein in aqua-feed legalised in EU

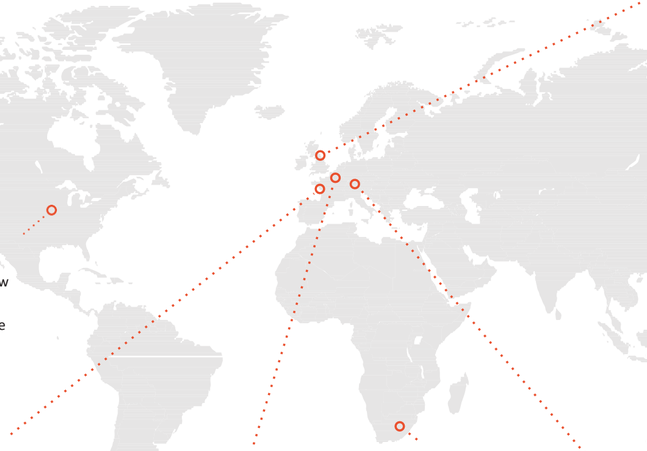
2030 – 2050 — By 2050 the global population is estimated to grow by two billion and it is predicted that global meat demand in 2030 will stand at 72% above the 2000 value of 233 million tonnes. The global production of aquaculture products has increased rapidly from about three million tonnes in 1970 to 90 million tonnes in 2012 and is the fastest growing animal food producing sector in the world. The World Bank expects fish production to grow by over 20% between 2010 and 2030 (PROteINSECT White Paper 2016)

Forecast Protein Gap



Source: Fao Working Paper on demand for animal source foods

Current Market Status at Janurary 2019



Canada

Legally approved for use in Salmonid and poultry feed in 2016

USA

Legislative bodies at state and national levels are changing legislation quickly in favour of insect meal and substrate use. Low government funding but high government attention to put enabling legislation in place (FDA approval for insects in salmonid feed in 2016; recommendation for inclusion in poultry feed in 2018).

France

Aims to become leading world supplier of protein by 2030 with an agreement signed between government and industry in 2016. Protein France industry consortium boosting investment into research, innovation and scale up on animal and vegetable and 'future' proteins such as microalgae and insects. French supermarket Auchan launched insect-fed trout in 52 of its supermarkets in northern France (December 2018).

Netherlands

- Government & Venik (Dutch Association of Insect Producers) signed Green Deal B92, a joint effort in lobbying and designing a framework for market approval for insect production at scale for feed & food applications.
- Permitted niche products such as insect lipid for piglet feed, proteins for hypoallergenic pet food and live larvae for egg producing chickens

South Africa

Insect based poultry and aquaculture feed approved

UK and Europe

- In 2013 the European Commission funded a €3 million project evaluating insects as a novel source of protein for animal feed - PROteINSECT
- Regulation No 2017/893, May 2017 authorised the use of insect proteins (processed animal proteins [PAP]) originating from seven insect species (including BSF) in feed for aquaculture animals. Only feedstuffs currently approved for animal feed are permitted for insect rearing i.e. pre-consumer agri-food residues known as 'former food products' including out of specification food, potato chips or breakfast cereals; leftover dough and liquid chocolate, surplus bread collected from retailers and bakeries.
- Insect derived oil/fats can legally be used in any livestock feed, but retailers restrict the use of tallow, fat and lard. There is a lack of legislation and regulatory alignment.
- Bio-fertilisers derived from insect rearing; with AVLA approval would fall within the existing framework permitting land spreading of compost, AD and sewage sludge.

EU

Following a vote of EU members, the European Commission amended the regulation No 2021/1372 to allow the use of insect PAPs in poultry and pig feed effective from September 2021 for EU Member States.



Insects for use in animal feed – Market Situation in the EU

The applications:

Insects are currently permitted for use in pet food and aquaculture. European pet food companies are utilising insect meal but not from UK insect producers. Live insects can be fed to poultry but delivery on a practical scale has not yet been realised in the UK.

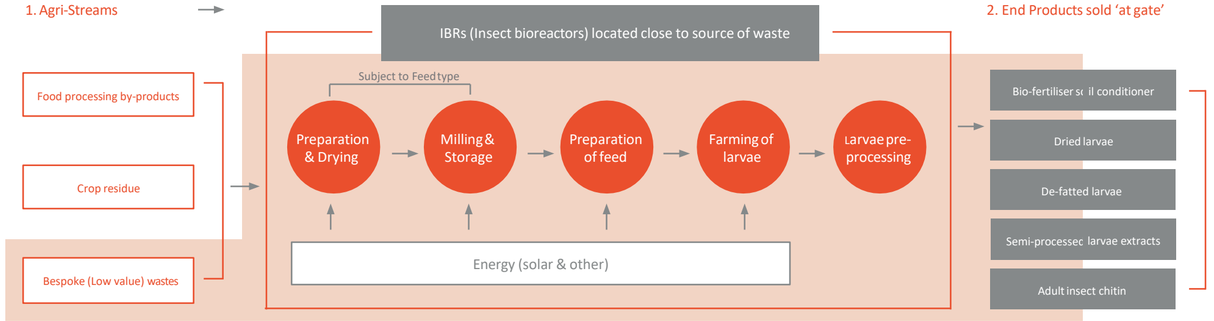
- Following authorisation in 2017 the aquafeed market has consumed approx. 500 tonnes of European produced insect meal and this is expected to rise (International Platform for Insects in Feed and Food- IPIFF; Vision Paper 2018); none of this is currently produced in the UK
- Insects are primarily used in niche, exotic pet food markets, such as live feed for reptiles (crickets, locusts and mealworms); Monkfield Nutrition (UK market leader) produces ~700kg dried insects per week. Several European pet food companies already incorporate insects in their feed to diversify their product range e.g. aquarium fish feeds, hypoallergenic products
- Wild bird feed mixes and suet blocks incorporate insects and are almost always imported from overseas/China

Potential for insect biomass, processed products and rearing residues in the following sectors:

- High quality, sustainable protein products for pet food, aquaculture, poultry and pig feed.
- Improved animal welfare. Processed BSF fat and chitin have potential as bio-actives.
- High value by-products such as chitin (e.g. medical applications, bio-degradable packaging) and fats/lipids (e.g. biofuels)
- Enhanced valorisation of waste streams/side-streams
- Waste remediation and volume reduction such as animal manures
- Insect residues as bio-fertilisers and/or substrates for AD bioenergy production

What is an insect bioreactor?

Large scale farming of insects is proven and uses the following processes:



Scale and Route to Market

Potential scale of insect production based upon the use of agri-food waste for the UK is difficult to determine. In principle with >9 mt of food waste available, at c. 20% conversion this gives an estimate of 1.8 million tonnes insect meal per annum. (or c. 1800 kt protein; 1200 kt fat).
A single commercial insect farm has a potential (and further scaleable) annual output of 5600 tonnes of meal, 2.8 million litres of oil and 21 000 tonnes of soil conditioner.

- The potential scale of annual UK demand; aquaculture feed is c.70 kt protein (inclusion rate of 23%); c. 200 kt of dried meal for poultry feed (5% inclusion rate); > 100 kt for pig feed (5% inclusion rate)
- The potential scale for pet food in the UK can be estimated as 20 kt protein per annum (based on a conservative 5% of the current market size).
- Route to scalable market for insect protein for compound feed is via accredited feedmills able to test, confirm quality, build reputation and trust; direct to farm potential for large pig/poultry producers able to manufacture own feed.
- UK potential to build/establish 12 'plants' in the short term (3-5 years) and 24 in the medium term (5-10 years); capacity is dependent upon a consistent supply of rearing substrate at appropriate scale.

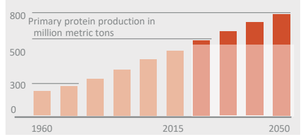
Insects contribute to a circular economy

Today's challenges

The increasing demand for meat puts pressure on our current animal feed protein sources such as soy and fishmeal. The limited availability of fertile land means that increased meat production will have considerable impacts on the environment. A huge amount of food doesn't even reach our tables.

The protein gap

Primary protein production needs to increase by 50% until 2050.





Today, 85% of arable land is already in use.

Meat production and consumption



Meat consumption will increase 50% by 2050, most of which in Asia, Africa, and mainly Latin America.



Four plant-based proteins are needed on average to make one animal-based protein.



Current feed proteins pose challenges.
The example of soy:

- 80% of production occurs in only three countries
- high price volatility in some regions of the world
- expansion of soy production is contributing to deforestation

Food waste and losses

One-third of the food produced in the world for human consumption is lost or wasted every year. 95% of food waste ends up in landfills.





Source data: UNFAO 2017 report on the future of food and agriculture

Today's solution

Insects are able to recover nutrients from organic residues and bring them back into the food value chain, thereby contributing to a circular economy. Since no fertile land is needed for their production, they are a promising and sustainable new source compared to today's main alternatives. Some species, such as the black soldier flay, are well-suited for growth on large scale.

Benefits of insects

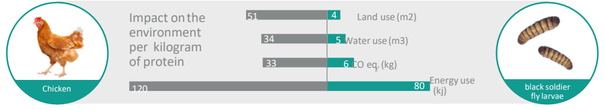


Insect proteins can be produced locally.



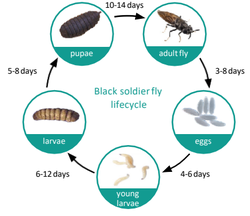
They are the natural diet of many animals.

Insects can be produced with little environmental impact.



The unique features of black soldier fly larvae

- Flexible feed -> They can grow on a large variety of wet and dry foodstock
- Fast growth cycle -> This makes efficient production possible
- Naturally live in high densities -> They are suitable for mass rearing
- High nutrient accumulation -> They are rich in proteins, lipids, and minerals



Nutrient recovery

Insects can recover up to 70% of proteins from organic waste.

Insects for Resource Reclamation

Supporting changing legislation

- The European Commission recently adopted a Regulation amending the TSE Regulation: Regulation (EU) N° 2017/893 partially uplifts the feed ban rules regarding the use of insect processed animal proteins (PAPs) for aquaculture animals. This new EU legislation was adopted on 24 May 2017 and the authorisation was officially applicable from 1st July 2017

Proving husbandry techniques

- Breeding and rearing a colony of insects is a key element of commercialisation of production of feed or valorisation of waste streams. Sustaining the 'livestock' to maintain the almost continuous process without issues, at scale is still yet to be fully proven

Research / Control standards for substrate quality and residue assurance

- Knowing the chemical and biological makup of the feedstock not only assures that the insects are able to thrive but also that no harmful toxins or microbial build up occurs during the rearing process. The products must also be assured against any build up of toxic residues, important for onward use of the protein or oils and lipids

Research into industrial applications

- Food and feed – Proteins for use in the food chain and recreational fishing and wildlife industry
- Reducing environment damage from a growing global population
- Improving soil health for UK farming - Research has shown consistent yield increases over 5yrs from insect derived biofertilizer
- Resource reclamation – Oils for biodiesel conversion and chitin for water treatment, filtering and packaging material applications
- Quality control standards for all products of waste conversion, protein, oils and chitin as all have commercial value and use from recycling

Fera leading key research into insect applications

- PROteINSECT EU funded project led by Fera Science Ltd. UK (partners across Europe, China & Africa) established the feasibility of obtaining high quality & safe insect meal and protein for animal feed from fly larvae reared on organic wastes
- ABAgri & Fera Science Ltd (UK Innovate funded) investigated use of fly larvae reared on chicken manure in poultry feed, demonstrating larval meal has comparable amino acid digestibility to commercial fishmeal
- Trials on cleaning plastics using insects as part of efficient recycling protein
- Agriculture, urban and industrial by-product research as potential for viable feedstocks
- Chair of 2018 UK Task + Finish Group on Insect Biomass report

Circular economy

The below illustrates the potential for combining insect technologies into a site wide campus circular economy, creating a regenerative system in which resource input and waste by-products, emissions, and consumption of energy and utilities are minimized. This can be achieved through deploying an insect bio-reactor alongside existing recycling and upcycling technologies.



The current legislative landscape limits development of the insect farming business model; Regulation No 2017/893, adopted by the EC, May 2017 authorised the use of insect proteins (processed animal proteins [PAP]) originating from seven insect species (including BSF) in feed for aquaculture animals. Only feedstuffs currently approved for animal feed are permitted for insect rearing i.e. pre-consumer agri-food residues known as 'former food products' including out of specification food, potato chips or breakfast cereals; leftover dough and liquid chocolate, surplus bread collected from retailers and bakeries. Insect derived oil/fats can legally be used in any livestock feed

Fera brings significant value to Feed / Food Manufacturers & Investors

Value added - assurance services to the food industry and Investors

- Fera project de-risking (pilot trials / nuturitional / safety testing / testing / risk assessments
- Fera ‘farm to fork’ assurance
- Fera training local scientists
- Fera audit / local quality certification
- Packaging and shelf life tests
- Test organic practices of suppliers
- Fera ongoing R&D programmes
- Test product for quality assurance assessment
- Risk assessment of new sites to ensure suitability
- Product safety assurance and regular testing
- Science partner for insect related R + D

Industry Assurance Partner

- Leading supplier of scientific solutions, evidence and advice across the agri-food / insect supply chain
- 100 years old UK Science institution
- Over 7,500 government and commercial customers
- Over 100 procedures accredited to ISO 17025
- Employs over 350 scientists and technical specialists
- UK’s National Reference Labs in 9 different areas

Without Fera

- Lower regulator confidence
- Lower investor confidence
- Lower feed buyer confidence
- Lower retailer confidence



Fera Insects R + D Assurance Services

- Situated within the National Agri-Food Innovation Campus, Fera has available state-of-the-art facilities and tools to support a wide client base providing complex analysis activities and consulting services – making use of current laboratory services, and linking to new capability emerging in the Aqua Eco-tox and Mesocosm facilities
- Fera is focused on providing services and scientific expertise to support and develop a sustainable food and feed chain using insects, and establishing Fera as the national recognised authority and trusted partner to industry in food/ feed safety and authenticity on insect solutions and products

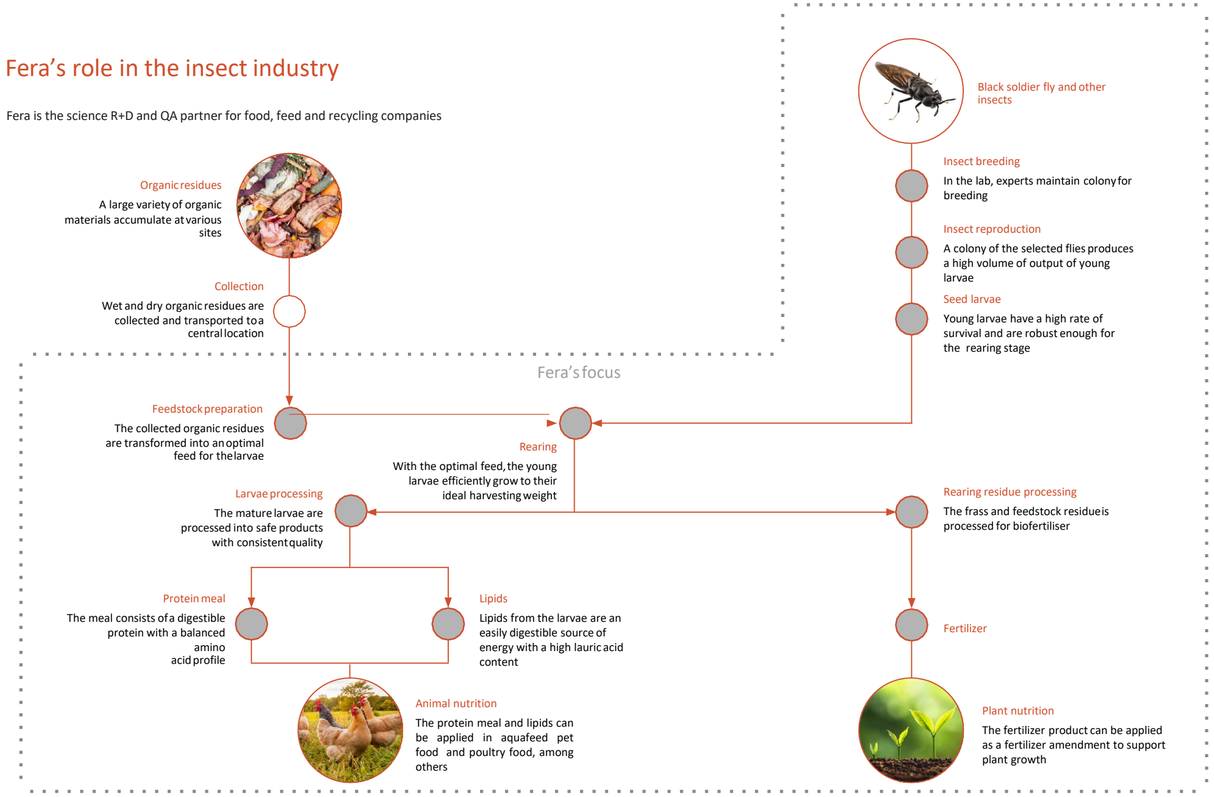
Services and solutions include:





Fera's role in the insect industry

Fera is the science R+D and QA partner for food, feed and recycling companies





Useful Stats- Legislation

2016

- Canadian Food Inspection Agency (CFIA) approved Enterra's BSF as a novel feed ingredient in poultry feed
- US Food & Drug Administration (FDA) approved use of BSF in salmonid feed

2017

- July 2017: European Commission authorized insect-based protein for aquaculture feed. 7 insect species permitted and can only be reared on substrates of non-animal origin

2018

- Task + Finish Group Insect Biomass report to UK Government

Summary

- Insect biomass presents a considerable number of opportunities for commercial exploitation on a global scale
- Nutritional quality of insect larvae is excellent (comparable to fishmeal) and highly suitable for use in mongastric and fish feeds
- Extensive safety screening suggests minimal risks and that potential risks can be mitigated by processing
- The potential to utilise large quantities of waste material offers significant environmental and economic advantages
- Further changes to legislation required to permit global use of insect protein in monogastric feeds
- Fera is an important partner in growing this nascent industry



...Original thinking... applied