PROteINSECT
INSECTS AS A SUSTAINABLE SOURCE OF PROTEIN

Insect Protein – Feed for the Future

Addressing the need for feeds of the future today

White Paper 2016

About the Authors

The White Paper 'Insect Protein – Feed for the Future' has been produced by Minerva Communications UK Ltd on behalf of PROteINSECT.

PROteINSECT is a three year (2013-2016) EU-funded FP7 project enabling the exploitation of insects as a sustainable source of protein for animal feed and human nutrition (PROteINSECT Grant Agreement Number: 312084).

PROteINSECT brought together expertise from China, Africa and Europe to encourage and enable the adoption of fly larval protein in animal feed around the world.
The PROteINSECT project consortium has 12 partners from seven countries and is co-ordinated by Fera Science Ltd in the United Kingdom.

PROteINSECT research focuses on five key areas in order to evaluate insects as a novel source of protein for animal feed and to ensure that methodologies are sustainable and economically viable:

1. The development and optimization of fly larvae production methods for use in both developed and developing countries at small and large scale.
2. Determination of safety and quality criteria for insect protein products.
3. Evaluation of processing methodologies and the evaluation of crude and refined insect protein extracts in fish, chicken and pig feeding trials.
4. The assessment of the optimal design of insect-based animal feed production systems utilising the results of a comprehensive life cycle analysis.
5. Creation of a pro-insect platform in Europe to encourage discussion about, and ultimately adoption of, sustainable production technologies to include examination of the regulatory framework.

For further information about the PROteINSECT Project please visit our website www.proteinsect.eu or email info@proteinsect.eu.

Dr Elaine Fitches
Co-ordinator of PROteINSECT
"Following three years of international research I welcome this opportunity to share our White Paper as a key stepping stone towards understanding the potential for the use of insects in animal feed in Europe."

Insect Protein Feed for the Future

Addressing the need for feeds of the future today

The protein gap in Europe is a very real risk to social, economic and environmental progress. Already reliant on importing 70% of our protein for animal feed, Europe faces added competition for feed protein from a global population that is set to exceed nine billion by 2050 and a growing appetite for animal products from developing nations.

As we seek sustainable European long term solutions we must consider the benefits that the introduction of insects - specifically fly larvae - could have on the content of animal feed.

PROteINSECT believes these highly effective protein converters offer great potential for Europe to become global contributors to the provision of alternative and additional innovative protein sources.

Contents **Page**

Introduction

The protein deficit

Increasing global populations and changing diets have led to the urgent need for additional supplies of protein from sustainable sources for inclusion in animal feed.

- Europe imports 70% of its animal feed protein.
- A five-fold increase in the total consumption of meat has been recorded globally since the mid 1940s.

The European Parliament has adopted a resolution to address the EU's protein deficit, stating that urgent action is needed to replace imported protein crops with alternative and additional European sources.

Aquaculture demand

Aquaculture production has been the fastest growing food producing sector over the last three decades and its growth is forecast to continue.

With this growth comes increasing demand for protein for fish feed and competition for feed inputs, especially protein related, with other forms of livestock.

EU waste burden

The European Union generates 88 million tonnes of biodegradable organic waste and as much as 1.4 billion tonnes of manure each year.

With growth in the consumption of animal products, organic waste is set to increase and we therefore need practical solutions to deal with this high volume, low value waste stream.

Your Questions Answered

Why are insects part of the solution?

Insects are rich in protein and are a natural component of the diets of many fish and free-range poultry. Fly larvae can be reared on a wide range of wastes and by-products offering a way of recovering value from materials that may traditionally be disposed of by agriculture and food industries.

The biological reprocessing of organic waste is a key concept underpinning PROteINSECT research into the use of insect protein in animal feed. Insects are not only able to provide the potential to extract protein from waste material but also facilitate significant reductions in waste volume. It has been shown that fly larvae can reduce the mass of organic waste by up to 60% in 10 days.

Is it feasible?

Commercial insect rearing exists both within and outside Europe with many more systems under development. PROteINSECT has identified further development opportunities including semi-automated systems more suitable for adoption in Europe; however it should be noted that European producers are already undertaking this work.

What about safety?

The European Food Safety Authority (EFSA) scientific assessment of the possible use of insects in feed states that when currently allowed feed materials are used to feed insects, the possible occurrence of any microbiological hazards are expected to be comparable to other sources of protein of animal origin and should not pose any additional risk compared to other feeds. PROteINSECT was a key contributor to the evidence base which made the assessment possible. The assessment does highlight the need for additional evidence and evaluation of the use of other (currently forbidden) substrates to feed insects destined for animal feed, such as organic wastes (food waste and manures).

Your Questions Answered

Do insects have good nutritional value?

PROteINSECT has advanced the state of the art understanding of the nutritional value of fly larvae for animal feed. Our research has demonstrated that fly larvae are rich in digestible protein, key amino acids, essential fats and micronutrients highly suitable for inclusion in animal feed.

Is it environmentally sustainable?

Compared to fishmeal, the evaluated house fly and black soldier fly production systems have shown favourable results in terms of impact on fossil fuel depletion, freshwater and marine eutrophication and ecotoxicity, as well as natural land transformation. PROteINSECT has identified possible improvements within the systems to further reduce heating related energy usage, labour and water inputs.

What do consumers think?

Consumer perception work undertaken by PROteINSECT has demonstrated a high level of acceptability of insects as a protein source in animal feed as well as a desire for more information about insects as an alternative sustainable protein source.

What barriers exist?

In the European Union, the use of insects as a source of protein for animal feed for animals raised for human consumption is currently not possible due to requirements under Regulation EC 999/2001. Under EC regulation 1069/2009, insects reared for the production of Processed Animal Proteins would currently be considered 'farmed animals'. It is not currently permissible to feed farmed animals manure or catering waste.
PROteINSECT continues to provide European regulators with the latest research findings to support evidence-based policy making.

Food and Feed – Global Demand

Food security - a global challenge

The global population currently stands at seven billion and the United Nations estimates it will reach over nine billion by 2050. This, alongside the fivefold increase in global meat consumption since the 1940s, has resulted in increasing pressures on the production of protein-rich crops for animal feed.

The FAO estimates that nearly 80% of agricultural land is already used to graze and feed farmed animals and global meat demand is expected to rise to 72% above 2000 levels by 2030. Increasing demand for food (particularly meat, fish and eggs) has led to an urgent need for additional supplies of protein from sustainable sources for inclusion in animal feed.

As a result of the rapidly growing world population, income growth, increasing urbanisation and changes in lifestyles and food preferences, a 'livestock revolution' is taking place. With limited potential for increasing the global cultivated land area, and many of the major food crops showing only modest yield gains, it is apparent that an increase in the availability of protein sources for animal feed is required.

PROteINSECT research has demonstrated that the use of insect protein in animal feed to complement traditional plant sources could contribute to freeing up land to grow crops for direct consumption by the human populace and lead to a concomitant increase in food security.

The European Union protein deficit

In 2011 the European Parliament adopted a resolution to address the EU's protein deficit, stating the need for urgent action to replace imported protein crops with alternative European sources. The European Parliament highlighted a number of factors affecting the EUs protein deficit including:

Protein supply

- Total EU protein crop production currently supplies only 30% of the protein crops consumed as animal feed in the EU, with a trend over the past decade towards an increase in this deficit.
- The significant deficit in protein crop production resulted from international trade agreements, especially with the United States, which allowed the EU to protect its cereal production and in return allowed duty-free imports of protein crops and oilseeds into the EU (GATT and 1992 Blair House Agreement).

Protein demand

- 70% of consumed raw materials rich in plant proteins are imported, mainly from Brazil, Argentina and the USA; approx. 60% of these imports (26 million tonnes) are by-products derived from vegetable oil production and are used as meals, especially soymeal, for animal feed.
- Imports represent the equivalent of 20 million hectares of cultivated land - more than 10% of the EU's arable land.
- Global producers are not subject to the same environmental, health and GMO regulatory constraints as European producers.

Protein international trade

- New customers for South American suppliers, notably China, may weaken the stability of the markets and the EU supply chain.
- The EU livestock sector remains vulnerable to price volatility and trade distortions, and depends on affordable and high quality protein imports.
- Shortages of protein rich soya and maize imports impose an additional cost burden on the EU livestock and feedstuffs sectors, and put the economic viability of domestic meat production at risk.

Reducing the protein deficit by rebalancing the supply and consumption of cereals, proteins and oilseeds in the EU could have major economic benefits for farmers and the food and feed industry and provide a better balance of protein production whilst contributing to improved global food security.

Aquaculture demand

In the last three decades aquaculture has grown at rates exceeding all other animal source food categories and has become a worldwide industry that now provides half of the total global volume of fish consumed by people. Aquaculture production by the 28 European Union Member States (EU-28) reached 1.108 million tonnes and a value of €3.365 billion in 2012 and showed growth of 3.4% and 3.8% respectively, on the previous year (Eurostat). This rapid aquaculture growth raises protein feed supply concerns.

Increasingly aquaculture has competed for feed inputs, especially protein related, with other forms of livestock. This is particularly pertinent with global fishmeal and fish oil sources; the FAO estimated that in 2014, 16.3 million tonnes of wild caught fish were processed into fish meal and fish oils, which were then incorporated and used in aquaculture feeds globally. Alongside fishmeal increasing volumes of imported soya are being used as protein sources in European aquaculture feeds. The global demand for protein for fish feed continues to increase alongside the demand for aquaculture outputs.

EU waste burden

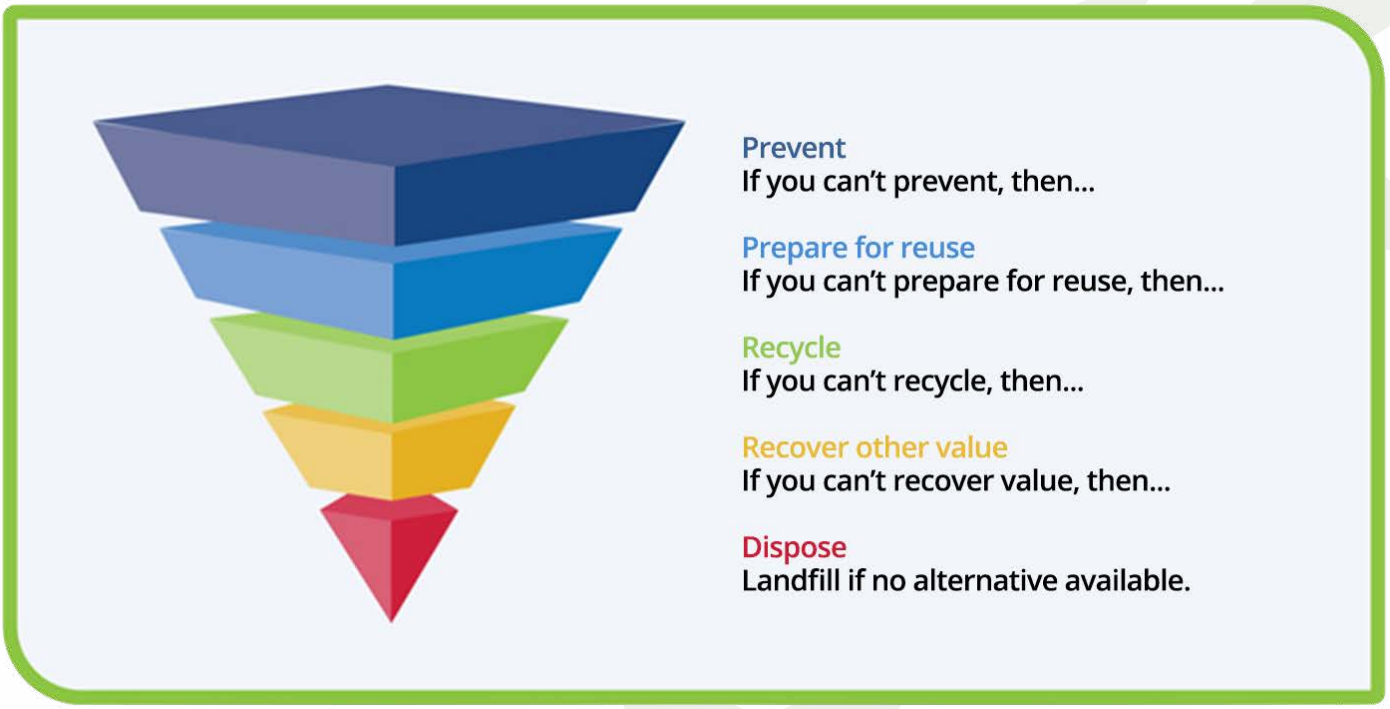
The European Parliamentary Research Service (EPRS) estimates that the EU food waste is approximately 89 million tonnes (180 kg per capita) per year, and is expected to rise to about 126 million tonnes a year by 2020, unless significant action is taken.

This, combined with the 1.4 billion tonnes of manure produced by EU member states annually, provides member states with a considerable organic waste burden unless waste reduction, re-use or reclamation using innovative solutions is implemented.

The EU Waste Framework Directive requires member states to take appropriate measures to encourage

- first, the prevention or reduction of waste production and its harmfulness;
- and secondly, the recovery of waste by means of recycling, re-use or reclamation or any other process with a view to extracting secondary raw materials, or the use of waste as a source of energy.

This is known as the waste hierarchy.



Insect Protein as Part of the Solution

Protein management

Insects are rich in protein and are a natural component of the diets of many fish and free-range poultry. Insect species considered most suitable for feed production include silkworms, mealworms, black soldier flies and the common house fly larvae. PROteINSECT research demonstrates that fly larvae can be reared on a wide range of wastes and offer a potential solution to the need to utilise increasing quantities of organic wastes. Additional benefits include the residual material after larval digestion which PROteINSECT is currently assessing as a fertiliser or soil conditioner with economic value.

Current land use constraints and the fluctuating cost of plant and fish derived protein provide a critical platform for the development of an approach to fully utilise insects as an additional source of protein for animal feed. The global adoption of insect protein production systems would support a reduction on current reliance on crop and fish based protein sources, and increase protein availability for animal feed, whilst also offering reductions in the environmental footprint of livestock production.

The production of protein extracts from insects for incorporation into foods provides an opportunity, for insect protein to achieve widespread exploitation directly in human diets in the medium to long term.

Plant based protein

In the light of the 'livestock revolution', and the concomitant growth in demand of the feed industry for protein, research has already been conducted to identify alternative and enhanced sources of protein for animal feeds. Investigations include the use of crop residues and co-products produced during the processing of crops for food (e.g. vegetable oil) and industrial uses (e.g. alcohol) and the use of genetic modification (classical breeding and biotechnological approaches) to improve the nutritional value of crops. However, with additional competing demands upon land-use for the production of crops for biofuel and the impacts of climate change on current and future crop productivity, the need to find additional protein sources for animal feed remains paramount.

Fishmeal based protein

Fishmeal is the major dietary protein source in compounded feed for many important and high value European farmed fish species. Limited fishmeal availability and quality of supply has driven research to identify alternative protein sources in order to meet growing demand. The levels of fishmeal in aquaculture feed have decreased substantially over the last decade as alternative feed sources become available. However, demand for fishmeal and soya meal protein continues to grow faster than the provision of new alternative sustainable protein sources.

PROteINSECT believes that fly larvae can provide Europe with an additional protein supply.

Insect Protein as Part of the Solution

Insect protein

The nutritional and economic value of insects in the context of protein substitution is dependent upon both total protein content and amino acid composition. Dipteran flies have a protein content and amino acid composition that renders them highly suitable for use as replacements to traditional plant and fishmeal sources. Other insect species are also suitable sources of protein, for example mealworms, but were not the focus of the PROteINSECT project.

PROteINSECT research demonstrates that house fly larvae contain relatively high levels of key amino acids such as methionine and lysine, providing a protein profile that is more comparable to fishmeal than plant based protein sources. As fishmeal prices are currently five times that of soyameal this adds significant economic incentive for the use of insect meal in animal feed. Additional nutritional components that add value to insect products include fats/oils and vitamins & minerals.

House fly and black soldier fly are rich in protein and have clear potential as a protein source in animal nutrition.

Processing technologies

PROteINSECT evaluated the most promising technologies for insect protein processing and established sound methodologies. These methodologies include killing approaches to ensure insect welfare is considered, as well as methods to ensure worker safety, including consideration of the potential for allergic responses.

Fly larvae from our own rearing systems in Europe, Africa and China have been assessed against innovative technologies at lab and pilot scale. Following this evaluation, PROteINSECT has concluded that solvent extraction methods achieve the best results for physical, chemical and enzymatic profiles.

Feeding trials

Fish, poultry, and pig feeding trials were conducted by PROteINSECT in 2015 in Europe (Belgium and UK) based on PROteINSECT UK derived insect protein. These trials evaluated weight gain and growth rates, as well as segment specific factors such as survival rates in Atlantic salmon parr.

Fish feeding trials
PROteINSECT conducted fish feeding trials on 3,600 Atlantic salmon parr over an eight week period and the results indicated that as compared to parr reared on commercial diets:

- Common house fly larvae can provide a suitable meal which can be used to replace up to half of the fish meal without affecting fish performance or proximate compositions of the whole body.
- Defatted insect meal has potential to replace more than 50% of fish meal in salmon parr diets.

Pig feeding trials
PROteINSECT conducted pig feeding trials on 48 male castrated piglets over a four week period at concentrations of 2% crude insect meal and 1.25% extracted insect proteins and the results indicated that as compared to piglets reared on commercial diets:

- No significant differences in body weight, daily gain, feed intake and feed conversion ratios were observed.
- Levels of good micro-organisms (Lactobacilli) were significantly higher in insect-fed piglets.
- No differences in levels of negative micro-organisms (Enterobacteriaceae and E.Coli) were detected.

Insect meal and extracted insect proteins in the piglet feed created a healthy environment within the gastro-intestinal tract of the animals.

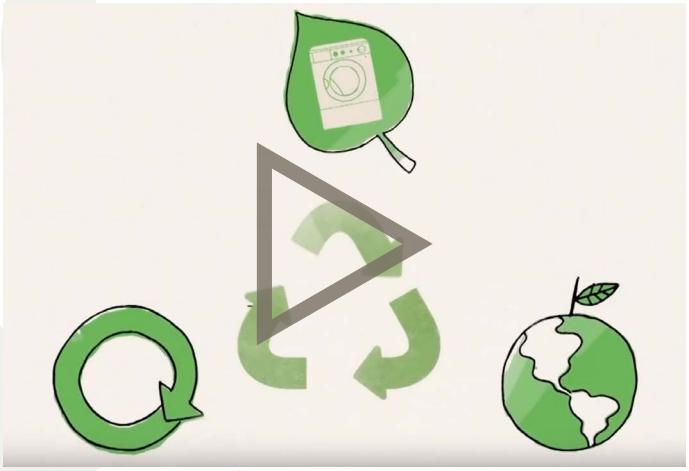
Poultry trials
PROteINSECT conducted poultry feeding trials on 300 male Ross chickens over a 39 day period at concentrations of 2% crude insect meal and 1.25% extracted insect proteins in comparison with birds fed on commercial diets and the results indicated that no significant differences could be observed in animal performance.

Supporting a European circular economy

A circular economy is one in which resources are kept in use for as long as possible. This is made achievable by extracting the maximum value from each resource whilst in use, then recovering and regenerating products and materials. The use of organic waste and manures as a feed substrate for the production of protein for feed, and a residual product for use as a fertilizer, matches the requirements of such an economy as it reduces waste, drives greater resource productivity and reduces the environmental impacts of existing waste disposal.

The predicted increases in livestock production that are likely to occur over the next 30-40 years will inevitably be mirrored by increases in waste mass. Whilst some uses are found for these wastes, such as compost and biogas generation, insects have the potential to utilise these wastes as food and convert it into high value materials, including protein. This biological reprocessing of organic waste is a key concept underpinning the use of insect protein in animal feed. These substrates therefore offer a suitable unexploited resource for the production of protein.

Insects are not only able to provide the potential to extract protein from waste material but also facilitate significant reductions in waste volume. Fly larvae can reduce the mass of organic waste by up to 60% in 10 days. The remaining digestate can then be exploited for added value in a number of ways because fly digestion only reduces the values of key elements (N, P, K, C) within the substrate by 40-60%, whilst also beneficially reducing the moisture content. Such uses include compost, fertiliser, soil remediation material and as a substrate for biogas generation. The use of residues as fertiliser is particularly attractive given the recent variations in global prices of chemical fertilisers, with prices fluctuating by more than 400% for particular blends over the last 10 years, and a growing demand for high quality organic fertilisers to maintain soil productivity.



Existing demand

The development of alternative and additional protein sources to feed the growing global demand for animal products is not a new concept. The European Feed Manufacturers Federation (FEFAC) estimates that the current value of livestock production in the 28 European Union Member States (EU-28) accounts for over 40% of the overall agricultural output. Purchases of compound feed have risen significantly over the last 15 years from under €30 billion to over €55 billion in 2012.

According to Eurostat, aquaculture production within Europe reached 1.108 million tonnes and a value of €3.365 billion in 2012 and showed growth of 3.4% and 3.8% respectively, on the previous year. EU aquaculture production is mainly concentrated in four countries: Spain, United Kingdom, France and Greece – all would benefit from reduced feed price fluctuations.

Future demand

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.

Infrastructure

Commercial insect rearing already exists both within and outside Europe.

In 2013 the International Platform of Insects for Food and Feed (IPIFF) was formed as a non-profit organisation representing the interests of private players in the insect industry. IPIFF brings together over 25 member-companies operating in the insect value chain, including members from over 10 different European countries.

The European insect industry is composed of a collaborative network of local partner companies that are promoting an insect industry as a sustainable eco-industry.

European commercial enterprises examples

- PROtix Biosystems BV in the Netherlands has developed scalable insect production systems using 'end-of-life streams' to produce insect meal and purified oil, as well as chitin as a basis for derivatives like chitosan.
- The Spanish spin-out, Bioflytech specialises in rearing a range of fly species producing biomass for animal feed with additional focus on the use of insects in the development of technologies for waste valorisation.
- Ynsect, a French company, has attracted €14m of investment to date which is focused on the development of fully automating its insect production and processing facility. Ynsect currently produce over one tonne of proteins and derivatives, lipids and chitin and derivatives per day.

Industry perspective

IPIFF welcomes the PROteINSECT White Paper 'Insect Protein – Feed for the Future' which highlights the benefits of using insects as a protein source in animal feed. IPIFF and its members are fully committed to ensuring food safety of insect products and are in compliance with relevant EU regulations. In line with this commitment, only vegetal based substrates are used to feed commercially raised insects. Furthermore, the IPIFF Members follow best hygiene practices, appropriate risk monitoring & management procedures and are certified under quality certification schemes (e.g. ISO standard 9001, GMP+). In view of these industry standards, the positive fish feeding trial outcomes of PROteINSECT & the industry as well as EFSA's recent risk assessment pointing towards the safety of Processed Insect Proteins when vegetal substrates are used, we strongly suggest to authorise their use in aquaculture, in line with other non-ruminant animal proteins. PROteINSECT's examination of the use of substrates currently banned in the EU is interesting from a long-term perspective. However, IPIFF members will only envisage commercial applications for insects raised on such substrates when full assurance on the safety of such materials has been provided.

IPIFF – the International Platform of Insects for Food and Feed – gathers the leading actors of the insect sector to promote insects as a top-tier source of animal protein for both human consumption and animal feed. IPIFF currently represents 27 members from 15 countries across Europe and abroad.

Consumer perception

One of the often cited challenges facing the use of insect protein in animal feed is public acceptance. In Western society a lack of a cultural history of eating insects means they are considered a novel food. With a number of high profile food scandals in recent decades consumers are becoming increasingly interested in how the food they eat is produced and the impact it has on the environment.

Consumer perception surveys undertaken by PROteINSECT in 2014 and 2015 (over 2,400 responses) have demonstrated a high level of support for insects as a protein source in animal feed, as well as a desire and need for more information to become available on the topic.

PROteINSECT findings demonstrate that approximately two-thirds of people surveyed rated the health risks of eating farmed animals that had been fed insect protein as 'no' or 'low risk'. This compares favourably to other protein sources such as GM crops, where less than 50% of respondents gave the same rating. 70% of respondents also rated feeding farmed animal insect protein either 'totally acceptable' or 'acceptable'.

If insect protein is to be introduced into animal feed, it is important that this is carried out in a transparent manner with consumers consulted and informed throughout the process.

Barriers to Market Implementation

Overview

Conservative and outdated European laws concerning the use of insects in feed and food are a major barrier to potential investors and thus market entry for insect-derived protein. Whilst insects present a new opportunity for Europe, exploitation requires the modernisation of existing legislation which was designed for traditional protein sources.

In order to support and encourage the development of industrial-scale insect-rearing plants, appropriate safety and quality data must be available so that the relevant current legislation and regulation can be reviewed.

PROteINSECT research is playing a central role in the generation of state of the art evidence on the safety of the use of insect protein in animal feed. Comprehensive analysis to determine levels of chemical and biological hazards in insect larvae reared on organic wastes from samples produced by PROteINSECT partners in the UK, Ghana, Mali and China has been presented to the European Food Safety Authority.

Legislation

In the European Union, the use of insects as a source of protein for animal feed for animals raised for human consumption is currently not possible due to requirements under Regulation EC 999/2001. Insect protein reared on plant-based material for pets is not covered by these requirements and is therefore permitted in pet food.

PROteINSECT has evidence to support the rearing of flies on organic substrates currently considered as waste produced by the agriculture and food industries. Under EC regulation 1069/2009, insects reared for the production of Processed Animal Proteins (PAP) would currently be considered 'farmed animals' and are therefore prohibited from being fed on manure or catering waste.

A complete assessment of the European legislative landscape affecting the use of insect protein in animal feed has been undertaken by PROteINSECT and is available to download here.

European Food Safety Authority (EFSA)

In October 2015 EFSA Scientific Committee published a "Risk profile related to production and consumption of insects as food and feed" (Question number: EFSA-Q-2014-00578).

The EFSA risk profile confirmed that when currently allowed feed materials are used to feed insects, the possible occurrence of any microbiological hazards are expected to be comparable to other sources of protein of animal origin and should not pose any additional risk compared to other feed. The risk profile also highlighted the need for:

"Further research for better assessment of microbiological and chemical risks from insects as food and feed including studies on the occurrence of hazards when using particular substrates, like food waste and manure."

The EFSA risk profile document also confirmed the important role that the EC-funded PROteINSECT research project has played in generating the knowledge and data on the quality and safety of the use of insect protein in animal feed. PROteINSECT's work will also help to fill the current 'uncertainties' and knowledge gaps identified in the Scientific Opinion.

Next Steps

The protein deficit in Europe is a very real risk to social, economic and environmental progress. Already reliant on importing 70% of our protein for animal feed, Europe faces added competition from a global population that is set to exceed nine billion by 2050, alongside a growing appetite for animal products from developing nations.

Through the development of a European insect industry, Europe has the opportunity to become a global contributor to this alternative and additional protein source and tackle the growing pressures associated with organic waste streams.

For Europe to embrace this opportunity and rear insects on organic waste for use in animal feed, PROteINSECT has identified through analysis of insect production, processing, safety and quality and the European legislative and consumer landscape two key actions that must be undertaken:

1. A review of Regulation EC 999/2001 and Regulation EC 1069/2009.
2. A commitment to undertake the necessary research to ensure that the required evidence is available for EFSA to carry out a full risk profile for insects reared on organic wastes.

The use of insect protein in animal feed to complement traditional plant sources could contribute to freeing up land to grow crops for direct consumption by the human populace and lead to a concomitant increase in food security for Europe.

Outreach activities - research with impact
Safeguarding the impact, reach and legacy of the PROteINSECT research project.
Dr Elaine Fitches talks to BBC Countryfile (Broadcast November 2015 to audience of 7 million).

PROteINSECT Project Partners

Fera Science Ltd

CABI

Nutrition Sciences N.V.

KU Leuven

Minerva Communications UK Ltd

eutema GmbH

GRANTBAIT

Guangdong Entomological Institute

Institute of Aquaculture
University of Stirling

Institute of Aquaculture
University of Stirling

Institut D'Economie Rurale

Fish for Africa

PROteINSECT

INSECTS AS A SUSTAINABLE SOURCE OF PROTEIN

www.proteinsect.eu

info@proteinsect.eu

PROteINSECT has received funding from the European Union's Seventh Framework Programme Grant agreement no. FP7-KBBE-312084