



Insects for Africa

Developing business opportunities for insects in animal feed in Eastern Africa

A.G. Vernooij and T. Veldkamp

Report 1150



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Wageningen Livestock Research

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Abbreviations

ICIPE	International Centre for Insect Physiology and Ecology
FAO	Food and Agriculture Organisation of the UN
TSE	Transmissible Spongiform Encephalopathy
SME	Small and Medium Enterprises
KMP	Kenya Markets Trust
AKEFEMA	Association of Kenyan Feed Manufacturers
BSF	Black Soldier Flies

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Foreword

In the innovation agenda of the Topsector Agri & Food - Seed Money Project (SMP-18007) - a study was conducted on "Developing business opportunities for insects in animal feed in Eastern Africa". Small and Medium Enterprises (SMEs) in the Agri & Food sector are supported in the start-up of innovative, international collaborations.

Recently insects that traditionally been eaten by humans in many parts of the world, also in Africa, have recently also been considered as human food in the western world.

Furthermore, there is an increased interest in using insects or insect products as feed for pets, pigs, poultry and fish. Apart from being collected from nature, insects can also be reared in confined industrial facilities. Western countries are now investigating the potential of this approach, prompted by the need to find alternative protein sources. These alternatives are needed because demand for meat products is increasing while the available land for livestock production is limited.

The combination of common use of insects as food and feed in African countries and the experiences of upscaling insect production in more industrial facilities is excellent to co-create new business for Dutch companies.

The project provides an analysis of the current state of utilization of insects for animal feed in East Africa, with special focus on Kenya and offers an overview of investment opportunities for Dutch companies and knowledge institutes involved in production and insect research and outlines potential relevant private and public partners.

This report presents the findings to develop a more comprehensive view on utilization of insects as an alternative protein source for animal feed in Kenya. The focus was not only on research and technology transfer, but also on investigating the options for knowledge utilisation and commercial opportunities through intensive collaboration with Dutch and Kenyan private companies and Dutch and Kenyan agricultural knowledge institutes active in insect rearing.

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Wageningen, January 2019

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Summary

The Seed Money Project “Insects for Africa” was initiated to determine the need for alternative animal feed ingredients and the options of insect as a potential source in Eastern Africa. The aim of the project is to solve a local system problem. A system problem is a problem that can only be solved through collaborative efforts of business, government and research institutions. Prerequisite for a seed money project is that a local problem owner or owners (companies and or governments) participates in the project.

The demand for animal protein is growing strongly worldwide, also in eastern Africa (Kenya, Tanzania, Uganda). Kenya is leading the production in the region, with an annual production of compound feed close to 1M tons. Uganda produces over 300,000 tons annually and Tanzania close to 100,000 tons.

The growth in animal feed production of close to 50% in Africa over the past five years, increases the demand also for protein ingredients. Due to their good potential for crop production, Uganda and Tanzania can produce adequate amounts of animal feed. Kenya however, with limited agricultural potential, depends for close to 70% on imports to meet the demand for animal feed ingredients.

Whilst all stakeholders involved realise that insects could potentially play an important role in protein ingredient supply, local experience with insects production for animal feed is only limited. Several small scale efforts are ongoing for own or village level consumption with support from ICIPE; a handful of medium size insect producers are currently active in the country. These can only provide to small-scale feed mills. The larger feed mills require much bigger volumes of consistent quantity and quality.

Legislation for use of insect in animal feed has been introduced in Kenya in early 2018, when the Kenya Bureau of Standards approved new rules that specify the requirements for dried insect products as sources of protein for compounding animal feed.

Insect production in Uganda has so far mainly been small-scale and largely focussed on use of insect as ingredient for human food only. There is very little experience on insect growing in Tanzania, apart from a project linked to urban waste recycling in Dar es Salaam.

Management levels and results of current project in Kenya are in need of professional improvement, despite them being very laudable efforts working on alternative protein provision. More research is needed on issues such as use of the most efficient substrate available, climate control in production rooms and the type of insects most suitable for Kenyan circumstances.

Options for involvement from the Netherlands are in the field of consultancy and knowledge transfer, additional research under local production environments, advice on mixing insects protein in compound feed and supply of medium-scale efficient insect production equipment.

1 Introduction

Insects are part of the human diet in many tropical countries (DeFoliart 2018). It is estimated that insects form part of the traditional diets of at least 2 billion people (Van Huis 2013). More than 1.900 species have reportedly been used as food. Globally, the most commonly consumed insects are beetles (Coleoptera) (31 percent), caterpillars (Lepidoptera) (18 percent) and bees, wasps and ants (Hymenoptera) (14 percent). Following these are grasshoppers, locusts and crickets (Orthoptera) (13 percent), cicadas, leafhoppers, planthoppers, scale insects and true bugs (Hemiptera) (10 percent), termites (Isoptera) (3 percent), dragonflies (Odonata) (3 percent), flies (Diptera) (2 percent) and other orders (5 percent) (FAO 2013). In Western countries, human consumption of insects is infrequent or even culturally inappropriate. The rapidly growing world population and depletion of our resources require rethinking of our food patterns and habits, particularly those relating to meat consumption. It is concluded that insects or insect products might be a good solution to contribute significantly to food and feed security (Van Huis 2013). Veldkamp et al. (2012) and Veldkamp and Bosch (2015) concluded that insects might be a good alternative for traditional protein sources in animal feed. The nutritional value of insects is comparable to commonly used protein sources in animal nutrition, such as: soya bean meal and fishmeal.

In The Netherlands, the insect sector expands and companies are upscaling their production capacity. Dutch feed manufacturers (Coppens Diervoeding and Agrifirm) already use insect products (insect oil) in feed formulation. Since 2017 it is allowed to use insect protein in feed for aquaculture but so far it is not allowed to use insect protein in feed for poultry and pigs due to TSE regulation (EC) No 999/2001 (Transmissible Spongiform Encephalopathy) and consists of a ban on the use of processed animal protein (PAP) in feed for farmed animals. In 2017 this regulation was adapted and since July 2017 it is allowed to use insect protein in feed for aquaculture. The approval to use insect protein in feed for aquaculture and an expected relaxation of the TSE regulation for use of processed animal proteins in feed for poultry and pigs in the near future increases the interest of the feed industry for insects as a protein source. Currently the price of insect protein is not competitive with traditional protein sources but upscaling of the insect sector and research on gaining extra value in insect products will decrease the cost price of insect protein. From a sustainable perspective, the use of insect protein in animal feed is beneficial for growing insects if substrates will be used that are not suitable to feed directly to livestock.

The combination of common use of insects as food and feed in African countries and the experiences of upscaling insect production in more industrial facilities is excellent to co-create new business for Dutch companies. This can be achieved by providing consultancy activities on insect rearing on larger scale, insect product processing and feed formulation in Eastern African countries (Kenya and possibly also Uganda and Tanzania) and new business for these countries by creating new sources of protein-rich feed ingredients for livestock (poultry and pigs). Provision of well-balanced feed rations is important for optimal growth performance of animals and an insect-based ration is an opportunity for an efficient protein provision in animal diets. Most companies in western Europe are currently focussing on *Hermetia illucens* (Black Soldier Fly), *Musca domestica* (Common Housefly), *Tenebrio molitor* (Yellow Mealworm), *Alphitobius diaperinus* (buffalo) and *Acheta domesticus* (House cricket) as insects for feed and food. In Kenya as well as in The Netherlands, black soldier fly is the most common insect species as protein source for feed. Therefore this study was mainly focussed on the feasibility to use black soldier fly larvae or product derivate of this insect species as animal feed.

2 Approach

Seed money projects are part of the instruments of the Topsector Agri&Food, aiming at starting innovative international partnerships with Dutch SMEs in the agri-food sector.

The aim of the project is to solve a local system problem. A system problem is a problem that can only be solved through collaborative efforts of business, government and research institutions. Prerequisite for a seed money project is that a local problem owner or owners (companies and or governments) participates in the project. The search for the right partners and the development of a proper business model is central to the project.

Seed Money Projects are a good way to explore international opportunities and where the business model is helpful to find the right network partners.

The Seed Money Project "Insects for Africa" aims to

- * (1) provide an analysis of the current state of affairs of utilization of insects for animal feed in East Africa and
- * (2) offer an overview of investment opportunities for Dutch companies and knowledge institutes involved in insect research and production and
- * (3) outline potential relevant public and private partners through:
 - * listing growth in demand for protein sources in animal feed
 - * describing the need for alternative protein sources for animal feed
 - * analyse which areas are most in need of new sources of protein in animal feed.
 - * summarizing the current regulations with respect to rearing of insects and the use of insects in animal feed

The findings will be integrated to develop a more comprehensive view on utilization of insects as an alternative source of protein for animal feed.

The focus is not only on research and technology transfer, but also on investigating the options for knowledge utilisation through intensive collaboration with Dutch and Kenyan private companies and Dutch and Kenyan agricultural education institutes active in insect rearing.

3 Developments in demand and availability of animal feeds in Kenya

Introduction: production and demand for feed.

The demand for animal feed is growing strongly in Africa. The number of feed mills has almost doubled over the past five year whilst total production has risen by almost 30%, making Africa the fastest growing continent for feed production in the world.

Table 1 Total commercial feed production in Africa (Source: (Alltech 2018)).

	2013	2014	2015	2016	2017
Total compound feed	30.97	34.57	36.13	39.5	39.14
Poultry feed	17	21.1	21	20.1	22.35
Cattle feed	10.7	11	8.64	10.9	12.1
Pig feed	0.4	1.1	2.3	2.1	2.2
Number of feed mills	806	1,150	1,210	2,081	2,068

Kenya is one of the leading livestock countries in Africa, with thriving dairy and poultry sectors and an upcoming pig sector.

The total annual feed production in Kenya is approximately 900.000 M tons (Alltech 2018), which is produced by some 120 feed mills which in total have an estimated installed capacity of 1.100.000 M tons. This is up from 843.000 M ton installed capacity in 2008 which by then produced a total 375.000 M tons (Githinji et al. 2009), showing a strong growth and efficiency improvement of the Kenya feed industry. According to these figures, underutilization improved from 56% in 2009 to 19% in 2016.

Most of the feed production is for poultry: layers 60%, broilers 10%, dairy cattle 20%, pigs 5 %, pets 3 % and the remaining 2% for equine and fish (Alltech 2018). This is consistent with the figures of 2007 (Githinji et al. 2009).

Roughly 70 % of the feed milling capacity is concentrated in Central Kenya (area between Nairobi and Mt Kenya), 5% in North Rift (Eldoret), 9% in Nakuru and 9% at the coast(Githinji et al. 2009). The remainder can be found other parts of the country.

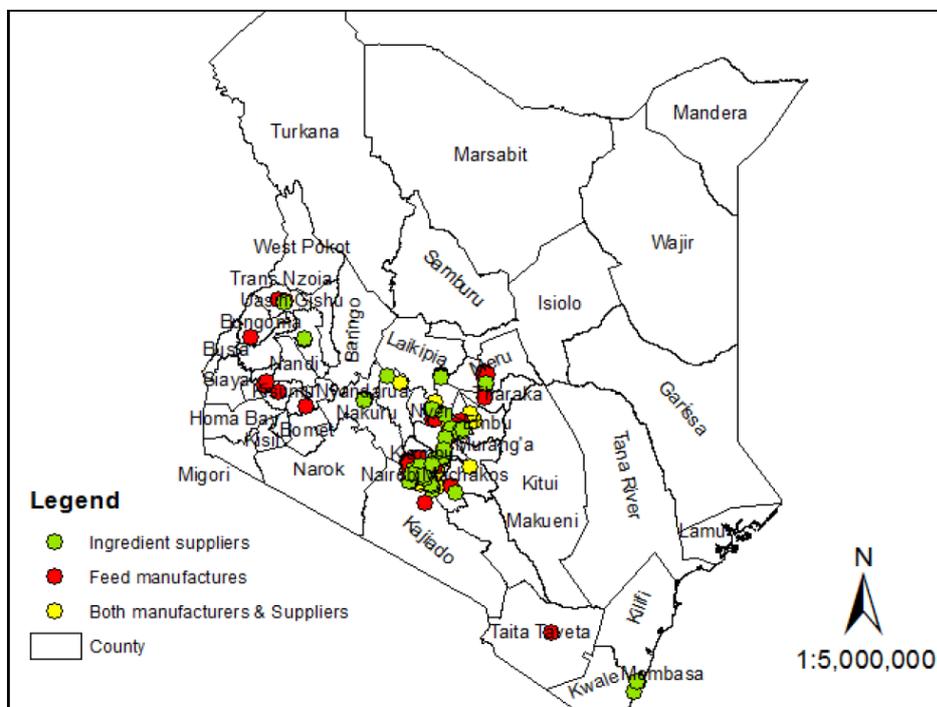


Figure 1 Concentration of feed industry in Kenya (source (KMP 2016))

KMP (2016) estimated that there are a total of 305 registered feed companies in the country, of which 115 who only manufacture feed, 96 who supplied raw materials (or ingredients) and 94 who did both. A large number of the so-called raw material suppliers does not have a fixed geographical address, they only work by connecting ingredient sources to ordering customers (manufacturers, distributors and even retailers) through their distribution and transport systems. The majority of manufacturers (over 80%) are small operations only capable of producing an average of about 500 tonnes/month. Almost a quarter of the surveyed manufacturers (26%) do not have resident feed formulation and a quality assurance specialist, half (53%) did not have a resident miller (KMP 2016).

The KMT study observes a rapidly growing and changing feed production industry with investors taking advantage of the growing demand for feed from developing intensive farming systems. The number of feed millers (209) is more than twice the number established in a 2008 survey by the Ministry of Livestock Development, which had identified and targeted 94 feed millers (Githinji et al. 2009).

The feed industry in Kenya is united in the Association of Kenyan Feed Manufacturers. AKEFEMA members list as their main challenges, in order of priority (Humphrey Mbugua, AKEFEMA director, personal communication):

- cost, availability and quality of raw materials
- high costs of electricity and transport
- debtors and credit control
- in availability of testing labs
- lack of knowhow in feed manufacturing technology.

Current (October 2018) prices for protein sources in Kenya are:

Table 2 Protein sources available in Kenya for animal feed (market prices gathered October 2018).

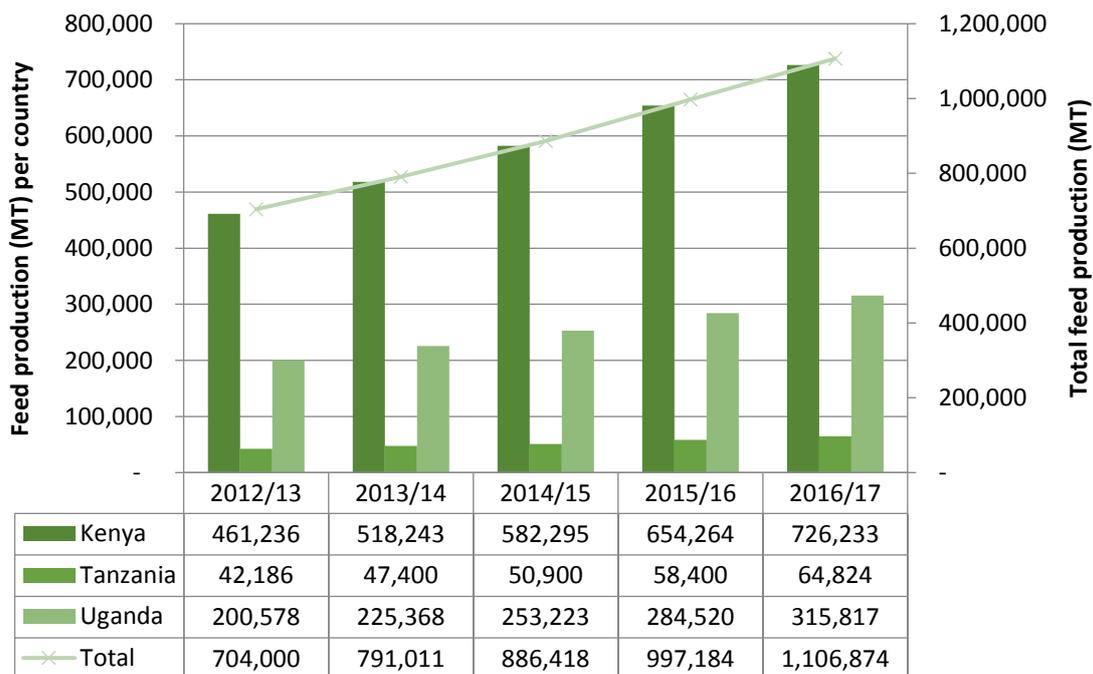
Product	Protein content %	Price (Ksh)	Protein Unit price (Ksh/kg)
Insect Meal	66	85	1.29
Fish Meal	51	100	1.96
Soybean Meal	49	75	1.53
Cottonseed Meal	44	28	0.64
Sunflower Meal	32	23	0.72

*Values are per kg of fresh product (10% moisture)

Regional developments in demand.

Also regionally in East Africa, the production of commercial compound feed has been growing strongly, mainly in Kenya and Uganda. Tanzania has a less well developed industry, with many farmers still buying their own ingredients and mixing their own feed.

Table 3 Source: Total feed production in East Africa.



NABC analysis based on FAO, USDA and World Animal Protection data, 2017, in (Vernooij et al. 2018).

Regional dependency.

The potential for a country to produce its own feed, mainly depends on the available agricultural land. Tanzania's potential to grow maize is high. Large parts of the country receive good rainfall and population pressure is much lower than in Kenya. Though Uganda has only slightly more ha's of land available for cultivation compared to Kenya, the potential is almost triple that of Kenya due to the good rainfall and fertile soils allowing for two to three rain-fed crops annually as compared to only one crop per year in Kenya.

Only 20 % of the land in Kenya is cultivable. The acreage of arable land in Kenya has grown from 4,000,000 ha in 2000 to 5,800,000 ha in 2014, according to figures of the Kenya National Bureau of Statistics. This growth however is only taking place on the marginal land extending from the high potential areas. The latest addition of 1 million ha to the land under cultivation has not led to any increase in volume of production, meaning that production per ha is only dropping due to increased utilization of dry and low fertile areas.

This leads to a situation whereby close to 80% of the raw material for feed production in Kenya has to be imported (Githinji et al. 2009; Vernooij et al. 2018), the vast majority of it from Tanzania and Uganda. Approx. 60% of the raw materials consists of maize and maize by-products. Most important protein sources are soybean meal (imported from India, Uganda and Europe); fishmeal and omena (Silver cyprinid, a sardine-like fish) from Uganda and Tanzania with some local production; cottonseed cake and cotton seed meal (from Tanzania and Uganda).

Companies and organisations in Kenya therefore adhere high importance to alternative feed ingredients which can be produced in Kenya itself, such as insects.

Poultry feed alone represents about 60-70% of the mixed feed sector in Kenya and Uganda. Fish feed however, represents less than 1% of the local feed market size. This is because commercial fish farmers import feed due to the high protein requirement of fish feed, that leads to its frequent adulteration on local markets. Fish feed processors as well as fish farmers therefore find in the insect based feed enterprise, an opportunity to produce and source reliable fish feed locally.

The protein ingredient, specifically fishmeal, remains the most and increasingly expensive part of the feed. The cost of fishmeal is higher in Kenya than Uganda, at US\$ 1.40/kg and US\$ 0.47/kg respectively in 2015. The situation is however worsening in both countries, with an increase of up 122% between 2013 and 2015.

While in Kenya 70% of commercial poultry farmers purchase feed, in Uganda, 53.3% of poultry farmers mix their own feed. However, the demands for ingredients remain high in both countries. Female-headed households used commercially mixed feeds more frequently than their male counterparts and were therefore more affected by increase in protein ingredients and feed costs.

4 Experiences in use of insects for food and feed in Kenya

4.1 Insects for food

The nutritional composition of the 1,900 edible insects so far recorded is highly variable. Therefore, it is difficult to generalize as to their food value (Cerritos 2009; DeFoliart 1992). Insect species as well as development stage and used substrates to grow the insects are likely to be important determinants of nutritional composition (Oonincx and Dierenfeld 2012).

Protein quality in relation to human requirements is measured by amino acid profiles and digestibility (Van Huis 2013). The fat content of food insects is variable among species, but the highest values are found in termites and palm weevil larvae (Bukkens 1997). The saturated/unsaturated fatty acid ratio of most edible insects is less than 40%, comparing favourably with poultry and fish, although the content of polyunsaturated fatty acids, linoleic and linolenic acids, is higher in insects (Van Huis 2013). When evaluating the importance of entomophagy (the practice of eating insects, the focus has often been on protein content. However, the very high amounts of important micronutrients in insects, in particular, iron and zinc, may be of considerably greater importance (Michaelsen et al. 2009). Iron and zinc deficiencies are widespread in developing countries, especially in children and women of reproductive age: Approximately 2 billion people are deficient in zinc and 1 billion have iron-deficiency anemia (Müller and Krawinkel 2005). Termites and crickets, commonly eaten among the Luo in Kenya, have high iron and zinc contents (Christensen et al. 2006). Chitin (the main component of the arthropod exoskeleton), chitosan (produced by deacetylation of chitin), and chito-oligosaccharides (degraded products of chitosan or chitin) have attracted considerable interest because of their biological activity, which includes immunity-enhancing effects (Lee et al. 2008; Muzzarelli 2010; Xia et al. 2011) and both promoting the growth of beneficial bacteria and inhibiting the growth and activity of pathogenic microorganisms (Muzzarelli 2010).

Processing edible insects into conventional consumer products seems to encourage entomophagy in Kenya, where termites and lake flies (Chaoboridae and Chironomidae) were baked, boiled, steamed, and processed into crackers, muffins, sausages, and meat loaf (Ayieko et al. 2010). The marginal areas of the Lake Victoria region often suffer lack of adequate protein in the diet due to heavy dependence on narrow base sources of protein, which is contributed by limited agricultural and livestock production (Grigg 1995). Edible insects could make a difference to levels of poverty and food security in many homes in Africa (Ayieko et al. 2010).

Kenyan consumers' responses to insects as food are generally positive despite the specific type of insects having important bearings on acceptability. Edible insects have the potential to play an important role in achieving food security and reducing micronutrient deficiency in Kenya (Alemu et al. 2017b; Alemu et al. 2017a). The consuming of insects is not new for Kenyans since most people, especially in the western part of the country, have tasted termites and other insects before, which can help the success of mass-production and introduction of insect-based food products in Kenya. This in return would call for the introduction of regulatory and quality control schemes that require great cooperation between insect commercialization companies and government agencies (Alemu et al. 2017a).

In addition to commercialization, farming insects can be important because this would increase food supplies at household level and generate cash incomes as well as create employment opportunities for the poor in rural Kenya. Similar conclusions are reported in other studies such as (Kelemu et al. 2015), (Ayieko et al. 2016), and (Halloran et al. 2016).

In Table 4, the most commonly eaten insects in Kenya are shown.

Table 4 Traditional Animal Source Foodstuffs and their edible parts consumed in Western Kenya

Common Name	Luo Name	Scientific Name	Edible Parts
Winged termite	Sisi	<i>Pseudacanthotermes militaris</i> (Hagen)	Whole: de-winged
Winged termite	Riwo	<i>Macrotermes bellicosus</i> (Smeathmen)	Whole: de-winged
Winged termite	Agoro	<i>Macrotermes subhyllanus</i> (Rambier)	Whole: de-winged
Winged termite	Oyala	<i>Pseudacanthotermes spiniger</i> (Sjostedt)	Whole: de-winged
Black ant	Onyoso	<i>Carebara vidua</i> (Smith)	Abdomen: de-winged whole
Long-horned grasshopper	Senesence	<i>Ruspolia differens</i> (Serville)	Whole: de-winged

Source: (Kinyuru et al. 2012)

4.2 Insects for feed

Main protein sources used in poultry feed in Kenya are: soya bean meal, sunflower seed meal, cottonseed meal and fish meal. Silver cyprinid fish (Omena) is often used as fishmeal. The market demand for silver cyprinid fish and soybean are high but available quantities are way below the demand, requiring importation. Furthermore the quality of Omena fishmeal is sub-optimal and varying due to the drying process of the fish. Very often a lot of sand is included in the fish resulting in ash contents of sometimes over 15%. Feed manufacturers have to separate the sand from the fish which result in extra labour costs and sand disposal. Replacement of 25% of protein in poultry feed alone in Kenya will require 27,000 to 32,000 tons of dried insects/year.

Considering that 100% protein substitution with Black Soldier Fly (BSF) in layers and broilers, demand for insect to substitute conventional protein source in feed in Kenya is estimated to 115,000 tons of dried insect annually for poultry feed alone (Fiaboe and Nakimbugwe 2017). Added to the potential for fish, poultry and pig industries, insect production for animal feed has a brilliant future. In the short term, insect use as protein source is estimated to reduce the protein cost in feed production by 25 to 37.5% and carries higher potential in the medium and long term where above 50% cost reduction could be envisaged.

The following list provides main data of the fish and poultry sector in Kenya, taken from the study of Fiaboe and Nakimbugwe (2017):

- A total of 388 poultry and 278 fish farmers participated in the survey in three counties Nakuru, Kisii and Kirinyaga. The majority of the poultry and fish farmer households, 87% and 86% respectively, were headed by males.
- The size of stock was above 50 heads per farmer only in intensive systems: layers (310 heads/farmer, 44.72% of poultry farmed through intensive system), broilers (241 heads/farmer, 34.78%), and local hens (120 heads/farmer, 17.32%).
- Tilapia, catfish and milacap stock were 93.2%, 6.55% and 0.24% respectively.
- About 70% of the sampled farmers who practiced intensive system of production used purchased feeds, and only 6% used own mixed feeds.
- Purchased mixed feed for adult birds was the most highly demanded feed at 68,154 kg, followed distantly by growers' mash at 14,087 kg and chick and duck mash at 8,606 kg.
- Majority of poultry and fish farmers (91% and 81% respectively) expressed awareness of use of insect as feed and 93% were willing to buy insects based feeds.
- About 98% and 93% of the female and male farmers, respectively, indicated that insects can form a good source of feed.

In the study of Fiaboe and Nakimbugwe (2017) overall 16 insect species were reared, the most vibrant colonies being black soldier fly (BSF, *Hermetia illucens*), crickets (*Acheta domesticus* and *Gryllus bimaculatus*), locust (*Schistocerca gregaria*), silkworm (*Bombyx mori*) and American

cockroaches (*Periplaneta americana*). Black soldier fly, which combined fastest population growth potential, absence of nuisance, waste management potential through conversion of a wide range of agricultural and municipal wastes into organic fertilizer and animal protein as well as low production costs has the highest market potential of these insect species to be used as protein source for feed (Fiaboe and Nakimbugwe 2017). The crude content of fishmeal on Kenyan and Ugandan market is 40.3% DM and crude protein of insect species is above the crude protein content of fishmeal, with for instance, field cricket (67.21%), house cricket (62.57%), and BSF (49.5%). Fish and poultry feed formulations in which 25% to 100% of fish protein was substituted with BSF protein were evaluated in the study of Fiaboe and Nakimbugwe (2017). Tilapia fed for 22 weeks with 33% protein substitution by BSF showed 23.4% higher weight gain than those fed on conventional feed. Broiler chicken fed on diets with up to 100% substituted protein had similar weight gain as those fed conventionally. Layer chicken fed diets with up to 100% BSF protein substitution from 31st to 52nd week of age laid better quality eggs, had 2.1 times higher average egg production in the last 10 weeks and significantly prolonged egg laying period compared to those fed on conventional feed. Feed manufacturers are searching for alternative protein sources to substitute Omena fishmeal and one of the alternatives is black soldier fly. In Kenya there is a high demand for black soldier fly as protein source for animal feed and recently companies are upscaling the production of black soldier fly. We have visited two companies producing black soldier fly in Kenya and both are in the phase of upscaling. First a breeding stock population has to be developed producing a required number of eggs in order to produce black soldier fly larvae for use in animal feed. One percent of the eggs produced by breeding stock is used to replace breeding stock and 99% can be used for larvae production as feed. One company reared black soldier fly larvae on municipal biowaste and the other company reared on human faeces. No regulations are available in Kenya on substrates that can be used to rear insects as feed. However feed manufacturers seem to refuse insects as feed that have been reared on human faeces.

International Centre of Insects Physiology and Ecology (ICIPE) has already trained more than 4,000 farmers on insect rearing so that they may have an alternative for animal feeds. These trainings are sometimes organised at ICIPE and sometimes on demonstration farms. They have made more than 35 feed formulations for poultry, fish and pigs. Also, they provide the farmers with insects and insect cages to help boost production.

Legislation

New legislation on use of insects in animal feed has been introduced in 2017. This was initially prepared by country's national animal feed technical committee in November 2016 and the committee then developed a draft standard, following a workshop in December 2016. The draft legislation was put to public consultation in January 2017 and the final approval was given in March 2018 (Annex14b-Kenya Final Approved Standard KS 2711_2017). This specifies the requirements for dried insect products as sources of protein for compounding animal feed.

Unlike in Europe, the rearing is not an issue. The focus is in the end product and ensuring there are not heavy metals, microbial or mycotoxins contaminants.

5 Developments in insect use in Tanzania

Insect production in Tanzania is still in its infancy stages. Few projects have been started so far, insect utilization in Tanzania, also for food, has always been less than e.g. in countries like Kenya and Uganda. In Tanzania, insects have traditionally only been eaten in the north west, in the areas around lake Victoria, where the local population appreciate the longhorn grasshopper (*Ruspolia differens*) as a delicacy (Mmari et al. 2017).

One major effort has been initiated to produce insects commercially, as a side activity of urban waste collection in Dar es Salaam. A British consultancy firm specialised in urban waste management has started a waste collection company in Dar es Salaam with insect production as an additional spinoff. The insect producing company uses black soldier flies to recycle collected food waste from local vegetable markets and sell the end product as protein source for chicken and fish feed.

A Norwegian company, Invertapro, has started trials with insect production in Morogoro in 2015, though current state of this venture is not known.

Some plans have been made by Sokoine University to investigate options for insect production, but none have been started off so far (email communication Prof Faustin P. Lekule).

Tanzanian feed industry is also interested in using insects as an ingredient for feed production. A company like Tanfeeds show high interest in using such alternatives (personal communication Eke Nijman, intern Netherlands Embassy Tanzania). Also the Poultry Association of Tanzania (personal communication Harko Bargath, chairman Poultry Association of Tanzania).

The combination of enough land to produce raw materials for feed and the still smaller commercial feed sector in Tanzania as compared to Kenya and Uganda, has led to fewer initiatives to date in Tanzania as compared to the surrounding countries in East Africa.

6 Conclusion and recommendations: options for Dutch involvement in insect production and utilization in Kenya

Due to Kenya's dependency on import of raw material for feed, there is a strong interest in insects as an alternative protein source for animal feed in aquaculture, poultry and pig production, also from the larger feed producing companies. However, the conditions of these companies, adequate volumes of consistent quantity and quality, cannot be met by current production levels.

Several initiatives to produce insects have been started in Kenya, mainly small-scale, with a handful of medium-scale producers. Small-scale production, often stimulated by training programmes from ICIPE is mainly for farmer's own feed where farmers mix their own feed or for selling to colleagues at village level.

The medium-scale producers supply small feed factories that do not require continuous large quantities as a condition to their standardised operations, but are more flexible in their use of ingredients than the large companies.

Management levels and technology used in the insect production process are often still experimental, with e.g. use of cleaning and drying equipment from the vegetable processing industry. Most of the work is done manually, hardly any of the work is automated.

Since investments in large scale insect production worldwide are only few, there is not enough experience yet on which to base a feasibility study for large insect production in Kenya, despite the wish of the larger feed companies in Kenya to do so as a first estimation to find out whether insects could be produced in Kenya at prices comparable to or preferably lower than the traditional protein ingredients for feed.

Summarizing, potentially the following Dutch involvement can be identified.

- Knowledge on production aspects. Management knowledge such as use of substrate to grow insects on, climate control in production rooms is still a limiting factor. Consultancy services can be availed to assist in the process of building up improved knowledge levels in insect production in Kenya.
- Availing research experience and facilities for testing material and methodology. As a follow up to the discussions during the mission with poultry integration, lab analyses on the suitability of chicken manure from floor systems using wood shavings as bedding is started, both in Kenya and the Netherlands.
- Equipment for medium scale insect production.
- Provision of eggs

The parties involved in the consortium recommend continuation of the project by undertaking two steps.

- (1) To first establish the availability of suitable feed stock in Kenya to grow insects on. The use of feed stock is essential in establishing an efficient production system. Different types of substrate are being used as feed stock at the moment, but more knowledge is needed

through surveys and research to identify the most efficient substrate, which is often a mixture of different material.

- (2) To expand the consortium with other interested parties from the Netherlands involved in producing insect production equipment and feed companies active in Africa. In Kenya, the consortium will be expanded with involvement of feed companies, poultry integrators, local insect producers and ICIPE.

A follow up proposal for a survey in Kenya investigating the most suitable substrate sources is in preparation.

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Related news items

Annex14b- Kenya Final Approved Standard KS 2711_2017

<https://www.feednavigator.com/Article/2017/11/17/Internationally-funded-project-behind-insect-feed-approval-in-Kenya-and-Uganda>

<https://smartfarmerkenya.com/insects-the-latest-craze-in-animal-feeds-sector/>

<https://www.nation.co.ke/business/seedsforgold/Why-I-am-rearing-insects/2301238-4533696-kla044/index.html>

<https://www.nation.co.ke/business/seedsforgold/insects-including-house-flies-give-the-best-fish-feed/2301238-3984262-3qI92rz/index.html>

<https://www.businessdailyafrica.com/news/counties/4-000-farmers-learn-how-to-rear-insects/4003142-4147096-10lrseez/index.html>

<https://www.feednavigator.com/Article/2017/11/17/Internationally-funded-project-behind-insect-feed-approval-in-Kenya-and-Uganda>

Appendix 1 Project proposal



TITLE: Insects for Africa: Developing business opportunities for insects in animal feed in Eastern Africa.

Project leader (From company or embassy): Hendrik de Vor, Coppens Diervoeding.

Requested budget: 40.000 €
Requesting country (only 1): Kenya.

Contact Project Leader:	<i>Organisation</i>	<i>Telephone No.</i>	<i>Email address</i>
Adriaan Vernooij	Wageningen Livestock Research	0317-480541	Adriaan.vernooij@wur.nl

Top sector **X Agri & Food**

1 Reason(s) for the project and its aims

1.1 Definition of the local problem, issue or opportunity

Globally, insects are being proposed as an alternative protein source for humans, livestock, and fish. In tropical countries, there is a history of insect consumption by humans. It is only recently that insects have been considered as human food in the western world. Furthermore, there is an increased interest in using them as feed for pets, pigs, poultry, and fish. In tropical countries, edible insects are traditionally harvested from nature. They contribute to food security, as they are often used for home consumption, or they provide a source of income when marketed. They are a seasonal product as most species depend on host plants and depend on the rainy season. Increased deforestation, agricultural intensification (e.g., pesticide use), and environmental pollution may threaten the resource, while higher demand and increased prices could lead to overexploitation.

Apart from being collected from nature, insects can also be reared in confined industrial facilities. Western countries are now investigating the potential of this approach, prompted by the need to find alternative protein sources. These alternatives are needed because demand for meat products is increasing while the available land area for livestock production is limited. The combination of common use of insects as food and feed in African countries and the experiences of upscaling insect production in more industrial facilities is excellent to co-create new business for Dutch companies. This can be achieved by providing consultancy activities on insect rearing on larger scale, insect product processing and feed formulation in Eastern African countries (Kenya and possibly also Uganda and Tanzania) and new business for these countries by creating new sources of protein-rich feed ingredients for livestock (poultry and pigs). Provision of well-balanced feed rations is important for optimal growth performance of animals and an insect-based ration is an opportunity for an efficient protein provision in animal diets. Nutritional composition of insect larvae is in fact comparable with that of fishmeal.

The proposal contributes to the innovation agenda of the Top Sector Agri & Food because this proposal includes new innovations as successful solutions for global challenges in the fields of agriculture and food focusing on the topics: 'Tasty, healthy and safe food for a growing world population', 'Climate neutral and robust food systems', 'Circularity and resource efficiency of chains and food systems', 'Strengthening of innovation and business earning capacity' and 'Valorisation in successful chains'.

1.2 Required knowledge: What concept is proposed to solve the local problem?

Dutch companies will benefit from the experience and knowledge on the common use of insects in the East African culture and East African countries will benefit from the knowledge currently gained in the Netherlands on upscaling of the production of insect larvae and inclusion of insect products in animal feed in order to improve sustainability of the animal production chain. Wageningen University & Research has an international leading role in knowledge on insect rearing and application of insects as animal feed. Wageningen Livestock Research (Teun Veldkamp) is president of the European Federation of Animal Science Study Commission on Insects and has a leading international role in sharing knowledge in the area of insects as feed.

1.3 Aim(s) of the project

The project will (1) provide an analysis of the current state of affairs of utilization of insects for animal feed in East Africa and (2) will offer an overview of investment opportunities for Dutch companies and knowledge institutes involved in insect research and production and (3) will outline potential relevant public and private partners through:

- listing growth in demand for protein sources in animal feed
- describe the need for alternative protein sources for animal feed
- analyse which areas are most in need of new sources of protein in animal feed.
- summarizing the current regulations with respect to rearing of insects and the use of insects in animal feed

The findings will be integrated to develop a more comprehensive view on utilization of insects as an alternative source of protein for animal feed. The focus is not only on research and technology transfer, but also on investigating the options for knowledge utilisation through intensive collaboration with Dutch and Kenyan private companies and Dutch and Kenyan agricultural education institutes active in insect development.

1.4 Economic opportunities & threats

Opportunities:

- Sharing knowledge on rearing of insects (small scale and large scale: what are the differences)
- Export opportunities for Dutch insect rearing companies
- Joint ventures with local insect rearing companies in Eastern Africa
- Making profit of the climate in Eastern African countries saving energy costs to produce insects
- Consultancies based on knowledge transfer on upscaling of insect production and use of insects products in animal feed

Threats:

- Insect production and local rules and regulations; these are very often unclear and need to be sorted out in this proposal
- Lack of knowledge in most countries on more industrially oriented forms of insect production

1.5 Social benefits or impact:

New employment in medium and larger scale insect producing units in Eastern Africa and applications of insect products in animal feed as a new protein-rich feed ingredient in animal feed.

2 Work plan

2.1 Describe methodology to show proof of concept and relate this to a planned time frame

The project implementation will consist of the following steps:

-literature review on recent developments in rearing of insects for feed	July/August
-interviews with stakeholders (private sector, RVO) in the Netherlands	August
-mission to selected countries for field research into insect rearing and issues including meetings with officials, one joint workshop with most relevant parties	September/October
-organise mid-term briefing in The Netherlands	Sept/Oct
-draft report on findings	November
-final presentation	December 2018

Before the start of the field mission, a detailed work plan will be presented to all participating stakeholders.

2.2 Outputs & deliverables

-detailed work plan before the start of the field mission 2018	August
-report of the literature review on recent developments in rearing of insects for feed	September 2018
-report of interviews with stakeholders (private sector, RVO) in the Netherlands 2018	October
-final report and presentation 2018	December

3 Project organisation

3.1 Project team (Wageningen UR)

Name	Organisation	Role	Email address	Telephone No.
Adriaan Vernooij	Wageningen Livestock Research	Project leader	adriaan.vernooij@wur.nl	0317 480 541
Teun Veldkamp	Wageningen Livestock Research	Researcher	teun.veldkamp@wur.nl	0317 480 769

3.2 Involved parties (besides Wageningen UR)

Name	Organisation	Role	Email address	Telephone No.
Roel Boersma	Protix	Knowledge on insect rearing and application of insect products in animal feed	Roel.Boersma@protix.eu	0621574603
Marian Peters	New Generation Nutrition	New feed concepts and experience in international projects (Flying Food)	marianpeters@ngn.co.nl	0617482653
Hendrik de Vor	Coppens Diervoeding	Feed formulation and feed processing to create a more balanced diet for livestock	VorHde@coppens.nl	0492531600
Gilian van Dijk	HAS Den Bosch	Insect research	g.vandijk@has.nl	0888903047
Jasper Heerkens	Aeres Hogeschool	Insect utilization in poultry	j.heerkens@aeres.nl	0880206000
Florence Mutua	University of Nairobi	Research and utilization insects	flmutua@yahoo.com	+254733546859
Frederick Wangombe	Joy Millers, Kerugoya, Kenya	Feed manufacturing company	wanfred2002@gmail.com	+254721403325

Appendix 2 Itinerary

Programme Kenya/Tanzania, SMP insects Oct 8-12, 2018.

AV Adriaan Vernooij
TV Teun Veldkamp
AN Asaah Ndambi

Monday 08-10-2018

			Venue
9.00	Preparatory meeting	(All)	Boulevard hotel
10.00 am	Fred Wangombe	(All)	Boulevard hotel
Afternoon:	Dr Tanga, ICIPE	(TV, AN)	ICIPE
14.00 hrs	Humphrey Mbugua, EKEFEMA.	(AV)	National Beekeeping Station
16.00 hrs	RaboBank, Kees Verbeek	(AV, TV)	Westlands, Delta Corner Tower, 17th floor.

Tuesday 09-10-2018

9.00 am	Lathyflora, Tallash Nannes	(TV, AN)	Limuru
10.00	Unga Farm Animal Care.	(AV)	Ngano House, Commercial Street, Industrial area
13.00	Sanergy.	(All)	Industrial area Nairobi.
15.30	KMAP Kenya Market Led Aquaculture Project.	(TV, AN).	FarmAfrica, Argwings K Argwings Kodhek Rd.
15.30	Agricultural Counsellor,	(AV)	Netherlands Embassy

Wednesday 10-10-2018

9.00	Meeting at Ecodudu failed (Unexpected public holiday)	(All)	Juja
15.30	Skype call The Recycler (Dar es Salaam)	(TV, AV)	

Thursday 11-10-2018

9.00	Fish farm KIAMUMBI Aquaculture Project	(TV)	Kiambu
11.00	Ecodudu	(TV)	Juja
14.00	Treasure Industries Ltd.	(TV)	Nairobi

In **Dar es Salaam**: Meeting with representatives the Recycler (AV).

Friday 12-10

Meetings with Tanzanian feed and poultry companies at the **Tanzania** Poultry Show 2018 (AV).

To explore
the potential
of nature to
improve the
quality of life



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Wageningen Livestock Research creates science based solutions for a sustainable and profitable livestock sector. Together with our clients, we integrate scientific knowledge and practical experience to develop livestock concepts for future generations.

Wageningen Livestock Research is part of Wageningen University & Research. Together we work on the mission: 'To explore the potential of nature to improve the quality of life'. A staff of 6,500 and 10,000 students from over 100 countries are working worldwide in the domain of healthy food and living environment for governments and the business community-at-large. The strength of Wageningen University & Research lies in its ability to join the forces of specialised research institutes and the university. It also lies in the combined efforts of the various fields of natural and social sciences. This union of expertise leads to scientific breakthroughs that can quickly be put into practice and be incorporated into education. This is the Wageningen Approach.

