



THE CONTRIBUTION OF INSECTS TO FOOD SECURITY, LIVELIHOODS AND THE ENVIRONMENT¹



WHAT IS ENTOMOPHAGY?

Entomophagy is the consumption of insects by humans. Entomophagy is practised in many countries around the world but predominantly in parts of Asia, Africa and Latin America. Insects supplement the diets of approximately 2 billion people and have always been a part of human diets. However, it is only recently that entomophagy has captured the attention of the media, research institutions, chefs and other members of the food industry, legislators and agencies dealing with food and feed. The Edible Insects Programme at FAO also examines the potential of arachnids (e.g. spiders and scorpions) for food and feed, although by definition these are not insects.

CAN INSECTS CONTRIBUTE TO FOOD AND FEED SECURITY?



Mealworms are sorted prior to freeze drying and packaging, Netherlands

Yes. Population growth, urbanization and the rising middle class have increased the global demand for food, especially animal-based protein sources. The traditional production of animal feed such as fishmeal, soy and grains needs to be further intensified in terms of resource efficiency and extended through the use of alternative sources. By 2030, over 9 billion people will need to be fed, along with the billions of animals raised annually for food and

recreational purposes and as pets. Moreover, externalities such as land and water pollution from intensive livestock production and over-grazing are leading to forest degradation, thereby contributing to climate change and other environmentally destructive impacts. Solutions need to be researched and explored.

One of the many ways to address food and feed security is through insect farming. Insects are everywhere and they reproduce quickly, and they have high growth and feed conversion rates and a low environmental footprint over their entire life cycle. They are nutritious, with high protein, fat and mineral contents. They can be reared on waste streams like food waste. Moreover, they can be eaten whole or ground into a powder or paste, and incorporated into other foods. The use of insects on a large scale as a feed ingredient is technically feasible, and established companies in various parts of the world are already leading the way in this regard. Insects as feedstock for aquaculture and poultry feed are likely to become more prevalent within the next decade.

WHY INSECTS?

The use of insects as food and feed has many environmental, health and social/livelihood benefits. For example:

ENVIRONMENTAL BENEFITS

- Insects have a high feed conversion efficiency because they are cold-blooded. Feed-to-meat conversion rates (how much feed is needed to produce a 1 kg increase in weight) vary widely depending on the class of the animal and the production practices used, but nonetheless insects are extremely efficient. On average, insects can convert 2 kg of feed into 1 kg of insect mass, whereas cattle require 8 kg of feed to produce 1 kg of meat.
- The production of greenhouse gases by most insects is likely to be lower than that of conventional livestock. For example, pigs produce 10–100 times more greenhouse gases per kg than mealworms.
- Insects can feed on bio-waste, such as food and human waste, compost and animal slurry, and can transform this into high-quality protein that can be used for agricultural feed.
- Insects use significantly less water than conventional livestock. Mealworms, for example, are more drought-resistant than cattle.
- Insect farming is less land-dependent than conventional livestock farming.

HEALTH BENEFITS

The nutritional content of insects depends on their stage of life (metamorphic stage), habitat and diet. However, it is widely accepted that:

- Insects provide high-quality protein and nutrients compared with meat and fish. Insects are particularly important as a food supplement for undernourished children because most insect species are high in fatty acids (comparable with fish). They are also rich in fibre and micronutrients such as copper, iron, magnesium, manganese, phosphorous, selenium and zinc.
- Insects pose a low risk of transmitting zoonotic diseases (diseases transmitted from animals to humans) such as like H1N1 (bird flu) and BSE (mad cow disease).

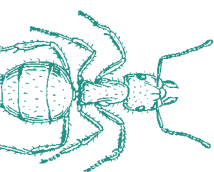
LIVELIHOOD AND SOCIAL BENEFITS

- Insect gathering and rearing can offer important livelihood diversification strategies. Insects can be directly and easily collected in the wild. Minimal technical or capital expenditure is required for basic harvesting and rearing equipment.
- Insects can be gathered in the wild, cultivated, processed and sold by the poorest members of society, such as women and landless people in urban and rural areas. These activities can directly improve diets and provide cash income through the selling of excess production as street food.
- Insect harvesting and farming can provide entrepreneurship opportunities in developed, transitional and developing economies.
- Insects can be processed for food and feed relatively easily. Some species can be consumed whole. Insects can also be processed into pastes or ground into meal, and their proteins can be extracted.



Monica Ayeiko

Rearing crickets in a plastic bucket using simple tools such as a saucer and cotton for drinkers and folded used carton papers to provide climbing and hiding places for the crickets, Kenya



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FROM GATHERING TO FARMING

“The domestication of insects is a very good idea. To me, it is crucial because it will enable local communities to produce insects so that they will be able to increase supply of insects and, at the same time, increasing production would mean an increase in their income ... Domestication of insects is a win-win approach. The insects will be sustainably produced and at the same time the livelihoods of rural communities will continue to improve.”
 Ousseynou Ndoye, FAO (Cameroon)

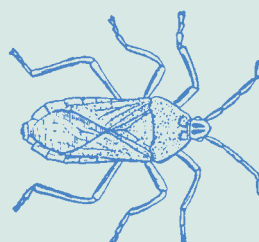
The majority of insect collection occurs through wild gathering, mainly in forests. However, modern science merged with valuable traditional knowledge and food culture can contribute to innovation and the scaling up of mass-rearing technologies. Farming insects as minilivestock offers great opportunities to increase supply without compromising wild insect populations.

NOT JUST “EMERGENCY” FOOD OR FOOD FOR THE POOR



Dried caterpillars at a local market in Southern Africa

A common misconception of insects as food is that they are only consumed in times of hunger. However, in most instances where they are a staple in local diets, insects are consumed because of their taste, and not because there are no other food sources available. Certain insect species, such as mopane caterpillars in southern Africa and weaver ant eggs in Southeast Asia, can fetch high prices and are hailed as delicacies.



WHAT ARE THE MOST COMMONLY CONSUMED INSECT SPECIES?

More than 1 900 edible insect species are consumed around the world. However, this number continues to grow as more research is conducted. The majority of these known species are harvested in the wild; however, few data are available on the quantities of insects consumed worldwide. From the data that are available, the most



Black soldier flies are reared in Spain to be used as a raw ingredient in animal feed

A FEED ALTERNATIVE

According to the International Feed Industry Federation, global compound animal feed production was 720 million tonnes in 2010. Insects can supplement traditional feed sources such as soy, maize, grains and fishmeal. Insects with the largest immediate potential for large-scale feed production are larvae of the black soldier fly, the common housefly and the yellow mealworm – but other insect species are also being investigated for this purpose. Producers in China, South Africa, Spain and the United States are already rearing large quantities of flies for aquaculture and poultry feed by bioconverting organic waste.

IS ENTOMOPHAGY DANGEROUS?

There are no known cases of transmission of diseases or parasitoids to humans from the consumption of insects (on the condition that the insects were handled under the same sanitary conditions as any other food). Allergies may occur, however, that are comparable with allergies to crustaceans, which are also invertebrates. Compared with mammals and birds, insects may pose less risk of transmitting zoonotic infections to humans, livestock and wildlife, although this topic requires further research.

commonly consumed insects are beetles (Coleoptera) (31 percent), caterpillars (Lepidoptera) (18 percent) and bees, wasps and ants (Hymenoptera) (14 percent). These are followed by grasshoppers, locusts and crickets (Orthoptera) (13 percent), cicadas, leaf and 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).

SCIENCE FICTION OR REALITY?

Although the base of entrepreneurial activities and formalized activities in insect farming is still small, initiatives to realize the potential of insects as feed and food are emerging. At present, insect farming takes place mainly at the small-scale, family-farm level and caters to niche markets. Insects have been farmed for a long time by the pet food and ornamental insect sectors, as well as the fish bait industry. Although rearing insects is technically feasible, a large constraint is that production can be more expensive than the production of traditional food and feed sources. However, current research suggests that insects can often be a more sustainable and cheaper alternative when external costs from harvest, production and transportation such as fresh water, greenhouse gas emissions and fossil fuel consumption are factored into the total costs of conventionally produced food. At present, the scale of current production cannot compete with conventional feed and food sources. Further mechanization is therefore a key issue in the growth of the industry. In addition, appropriate regulatory frameworks governing the production and trade of insects as feed and food need to be developed.

MORE THAN JUST FOOD



Bees play a vital role in the pollination of plants worldwide

Insects provide other important and useful functions beyond food and feed:

- **Insects are important providers of ecosystem services.** For example, insects play an important role in pollination, biological control and the decomposition of organic litter.
- **Insects are being tested to reduce livestock manure, such as that generated by pigs, and to mitigate foul odours.** Larval flies can be used to transform manure into fertilizer and consumable protein.
- **Insects have inspired human innovation for many years.** Biomimicry, which draws on the attributes of natural organisms and processes to spark innovation, has used the features of beehives, spider webs and termite hills to inspire the designs of a range of products and processes.
- **Insects have formed part of traditional medicine for thousands of years.** For example, fly maggots have been used to clean dead tissue in wounds, and bee products such as propolis, royal jelly and honey have been used for their healing properties.
- **The natural colour of insects has been exploited by different cultures for centuries.** For example, the Aztecs used the red colour produced by the cochineal (scale insect), and this insect is still used today as a natural food colouring in cosmetics and as a dye.
- **Silk, a product of silkworms, has been used for centuries as a soft yet strong and highly durable fabric.**

EXPLOITATION AND MANAGEMENT CONSIDERATIONS FOR WILD INSECTS FOR FOOD

The following should be considered in the protection of insect populations in natural environments:

- Consult the livelihoods and diets of local people in the management and conservation of natural insect habitats.
- Allow for sustainable harvesting of edible insects by local people within otherwise protected areas.
- Regulate the use of pesticides to avoid the bioaccumulation of pollutants in the food chain.
- Develop methods to monitor harvesting levels so that beneficial insect populations are not threatened.
- Integrate systems, where possible, for the domestication or semi-domestication of insects, in order to supplement insects caught through wild harvesting and to provide a constant supply where wild populations fluctuate according to the season.
- Avoid the release of non-endemic domesticated insect species into natural environments.

CREATING AND REVITALIZING LOCAL FOOD CULTURE

"... there needs to be a public forum or talk with chef participants from around the world to talk about the value in eating insects and talk about our recipes and cooking experiences. In order for this valuable food source to be a permanent part of our eating habits, insect recipes need to be varied and delicious, and this is where we chefs could bring our expertise in this hopeful and exciting field..." Meeru Dhalwala, Restaurateur, Canada and USA



Edible insects are prepared for a cooking competition in Laos

Despite the benefits of entomophagy, consumer disgust remains one of the largest barriers to the adoption of insects as viable sources of protein in many Western countries. Nevertheless, history has shown that dietary patterns can change quickly, particularly in a globalized world. The rapid acceptance of raw fish in the form of sushi is a good example of this.

Where entomophagy culture does not exist, it needs to be created. Even in countries that previously had a tradition of entomophagy, the influence of Western diets are affecting food choices, and eating insects may be looked down upon or shunned. Nonetheless, the insect trade is thriving in cities such as Bangkok and Kinshasa, and there is high demand from urban consumers. In such places, insects often arouse feelings of nostalgia for the rural countryside. In other cases, insects are seen as a snack.

From the creation of new recipes and menus in restaurants to the design of new food products, the food industry has a large role to play in raising the status of insects as food. Food industry professionals, including chefs, are experimenting with the flavours of insects. Insects can be found on menus in the West but are targeted mainly at adventurous eaters rather than mainstream consumers. A major barrier for the food service industry is obtaining a constant supply of insects in the quantity and quality needed.

WHERE DO WE GO FROM HERE?

"Research is required to develop and automatize cost-effective, energy-efficient and microbially safe rearing, harvest and post-harvest processing technologies as well as sanitation procedures to ensure food and feed safety and produce safe insect products at a reasonable price on an industrial scale, especially in comparison to meat products." (Rumpold and Schlüter, 2013)



Grasshoppers, known as chapulines in Oaxaca, Mexico, are a local delicacy

The Technical Expert Consultation on Assessing the Potential of Insects as Food and Feed in Assuring Food Security, held in Rome on 23–25 January 2012, highlighted the following key areas for research and development:

1) Mass-production technologies:

- Increase innovation in mechanization, automation, processing and logistics to reduce production costs to a level comparable with other feed and food sources.
- Develop feeding tables for insects and the nutritional value of substrates.
- Conduct more extensive life cycle assessments among a vast array of insect species to enable comparisons of insects with conventional feed and food sources.
- Maintain resilient genetic diversity to avoid colony collapse in insect farming systems.

2) Food and feed safety:

- Investigate the potential of insect allergies in humans and the digestibility of chitin (a principal constituent of the exoskeleton of insects).
- Expand data on the nutritional value of edible insect species and their contributions to animal and human health.
- Research the risk of potential zoonosis, pathogens, toxins and heavy metals (through the use of bio-waste streams) from entomophagy.
- Develop means of increasing shelf life.

3) Legislation:

- Develop voluntary codes and regulatory frameworks governing insects as food and feed, as well as human health and animal welfare at the national and international levels (e.g. the Codex Alimentarius).
- Improve risk assessment methodologies for risks related to mass-rearing and wild gathering in order to safeguard against the introduction of alien and invasive insect species to wild populations.

4) Consumer acceptance and education:

- Support entomophagy in cultures where it is already prevalent.
- Conduct comprehensive research into the ecology of species promoted for consumption or farmed.
- Educate consumers on the benefits of entomophagy.
- Develop new ways of integrating insects into the diets of a broad range of consumers through the creation of insect-based products.
- Promote insects as a supplement to feed.

KEY REFERENCES

- DeFoliart, G.R.** 1997. An overview of the role of edible insects in preserving biodiversity. *Ecology of Food and Nutrition*, 36(2–4): 109–132.
- FAO.** 2010. *Forest insects as food: humans bite back*. Bangkok, FAO.
- FAO/WUR.** 2012. *Expert consultation meeting: assessing the potential of insects as food and feed in assuring food security*. P. Vantomme, E. Mertens, A. van Huis & H. Klunder, eds. Summary report, 23–25 January 2012, Rome, FAO.
- FAO/WUR.** 2013. *Edible insects: future prospects for food and feed security*. Rome, FAO.
- International Feed Industry Federation.** 2011. Annual report 2010 [available at www.ifif.org/uploadImage/2012/1/4/f41c7f95817b4c99782bef7abe8082dd1325696464.pdf].
- Kuyper, E., Vitta, B. & Dewey, K.** 2013. *Novel and underused food sources of key nutrients for complementary feeding*. Alive and Thrive Technical Brief. Issue 6, February.
- Oonincx, D.G.A.B., van Itterbeeck, J., Heetkamp, M. J. W., van den Brand, H., van Loon, J. & van Huis, A.** 2010. An exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption. *Plos One*, 5(12): e14445.
- Rumpold, B.A. & Schlüter, O.K.** 2013. Nutritional composition and safety aspects of edible insects. *Molecular Nutrition and Food Research*, 57(3): DOI:10.1002/mnfr.201200735
- Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. & de Haan, C., eds.** 2006. *Livestock's long shadow: environmental issues and options*. Rome, FAO.
- Veldkamp, T., G. van Duinkerken, A. van Huis, C.M.M. Lakemond, E., Ottevanger, E. & M.A.J.S van Boekel.** 2012. *Insects as a sustainable feed ingredient in pig and poultry diets: a feasibility study*. Wageningen UR Livestock Research, Report 638.



FAO & EDIBLE INSECTS

Since 2003, FAO has been working on topics pertaining to edible insects in many countries worldwide. FAO's contributions cover the following thematic areas:

- the generation and sharing of knowledge through publications, expert meetings and a web portal on edible insects;
- awareness-raising on the role of insects through media collaboration (e.g. newspapers, magazines and TV);
- the provision of support to member countries through field projects (e.g. the Laos Technical Cooperation Project);
- networking and multidisciplinary interactions (e.g. stakeholders working with nutrition, feed and legislation-related issues) with various sectors within and outside FAO.

Further information about the work of FAO on edible insects is available at: www.fao.org/forestry/edibleinsects

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