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Science meets Comics

Proceedings of the Symposium on Communicating and Designing the Future of Food in the Anthropocene

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Arnold van Huis is Emeritus Professor at Wageningen University in the Netherlands. He worked from 1974 to 1979 in Nicaragua and from 1982 to 1985 in Niger. From 1985 onwards, he worked as tropical entomologist at Wageningen University. He is a world leading expert on insects as food and feed. In 2013, he published *Edible insects: future prospects for food and feed security,* together with the Food and Agriculture Organization of the United Nations (FAO), which has been downloaded seven million times. He is also the first author of *The Insect Cookbook* published in 2014 by Columbia University Press. In 2014, he organized together with the FAO a conference entitled *Insects to feed the world*, attended by 450 participants from 45 countries.

Arnold van Huis

Insects, the New Food?

Introduction

In many parts of the world it is common to eat insects while in the western world it is regarded as a bizarre habit, even evoking disgust. Is this justified? What if insects were nutritionally similar to our common meat products and have proven to be delicious in blind tests? Insects have an environmental impact which is much less than our common production animals, so why not eat it? If these questions can be answered affirmatively, then the question is: Can we persuade the western consumers to take this psychological barrier? There has been a tremendous interest during the last five years to promote insects as food. There are now close to 200 start-up companies listed (Bugburger 2017). Also, in the scientific world the interest is growing exponentially, testified by the number of articles on edible insects that have appeared during the last 15 years (83 from 2011 to 2015 against 9 from 2001 to 2005[1]). These articles deal with harvesting from nature, environmental benefits, nutritional value, food safety, processing, and consumer attitudes. I will give a short overview of the developments in these different areas.

From harvesting in nature to rearing

Edible insects in the tropical world are collected from nature, often in forests, and have therefore been termed 'non-wood forest products'. Why in the tropics and not in temperate zones? Very likely because insects in the tropics are larger in size, and are – in the absence of a winter – available throughout the year. Also, they often occur clumped, thus facilitating harvesting. In Mexico, the grasshopper, *Sphenarium purpurascens,* is a pest of maize and beans. However, since prehistoric times this species, locally called 'chapulines', can be handpicked instead of using pesticides, and provide hundreds of tonnes of food for human consumption (Cerritos et al. 2015).

It has sometimes been erroneously suggested that people in the tropics eat insects because they are starving, i.e., using it as a survival strategy. However, insects on local markets are often more expensive than common meat products indicating that they are considered delicious. This was demonstrated in early 2016 by a BBC documentary in Cameroon where the demand for palm weevil larvae was soaring because demand outstripped supply (Ford 2016). The solution proposed in this

1 Web of Science searching for 'edible insects' (accessed Feb. 2017).

country was to rear them on pieces of raffia palm in plastic boxes increasing harvest by 8 to 10 times. When promoting insects as food, rearing or farming, insects are a solution. In Thailand, crickets are favoured food and although there are 20,000 farms producing more than 7,500 tonnes a year, the demand is so high that crickets from neighbouring countries are imported (Durst/Hanboonsong 2015, Hanboonsong et al. 2013).

So when promoting insects as food, the animals need to be farmed, and that is why reared insects are referred to as mini-livestock. Mealworm larvae are reared in trays, crickets in plastic containers, and grasshoppers in cages. This requires quite some labour, which is why the price for the latter is often still too high. So companies are now investigating how to automate production processes. Also, the substrate on which the insects are reared receive attention as, in principle, it would be possible to rear the insects on organic side streams.

Nutrition

Are insects nutritious? This question is difficult to answer because we are talking about more than 2000 different species. Also, the nutritional value depends on many factors, such as rearing conditions, the diet, and in which stage the insects are harvested (Finke/Oonincx 2014). Even processing has an influence on nutritional quality. Then, the analytic methods used to determine the nutrients are also of importance. But generally speaking, many edible insect species provide satisfactorily with energy and protein, meet amino acid requirements for humans, are high in mono and poly unsaturated fatty acids, and rich in several micronutrients (Rumpold/Schlüter 2013). One study even showed that crickets, palm weevil larvae, and mealworms had a significantly healthier Nutrient Value Score than beef and chicken (Payne et al. 2015).

Why insects?

Why should we replace our current meat products by insect products? One answer would be 'out of necessity' to satisfy the increased demand for meat. This may be not so much in the case for the developed countries where meat consumption per capita from 2010 to 2050 will remain similar (Europe at 72 kg) or declines (USA from 110 to 95 kg), while in Africa and Asia it will increase from 17 to 28 and 32 to 48 kg, respectively (Revell, 2015). On a global scale this means an increase of 66% from 287 to 476 million. But 68% of all agricultural land is already under permanent pasture (FAOstat 2013, consulted March 2016), while about one third of all cereal production is used as feed for livestock (FAO 2002). This amount would be able to feed 3 billion people (Eisler et al. 2014). So, in order to meet future meat demands, we

need alternative protein products. A study on land use for producing protein from mealworms indicated that much less land was required than that from chickens, pigs, and cattle (Oonincx/Boer 2012).

Also livestock is responsible for more than 14% of global greenhouse gas emissions (Gerber et al. 2013), while, for example, mealworms produce much less (Oonincx/Boer 2012). It has been estimated that for producing one kg of beef up to 43,000 liters of water may be required (Pimentel et al. 2004). In a study comparing mealworms with chicken, pork, and beef it was shown that the amount required for producing mealworms was 23 liters per gram of protein, while for chicken, pigs, and beef it was 1.5, 2.5 and 4.9 times as much (Miglietta et al. 2015). The efficiency of the insect to convert feed into edible body weight is much higher than that for the animals: Crickets turn 2.1 kg of feed into 1 kg of edible body weight, while the production of one kg of edible body weight of poultry, pork, and beef requires 4.5, 9.1 and 25 kg, respectively (van Huis 2013) (Fig. 1). This is very likely so because the cold-blooded insects do not need to feed in order to maintain a body temperature. There is one other advantage of producing insects over the common production animals. Insects can be reared on remains of fruits and vegetables, as was shown by Ramos-Elorduy et al. (2002) for mealworms. However, food safety issues need to be considered.

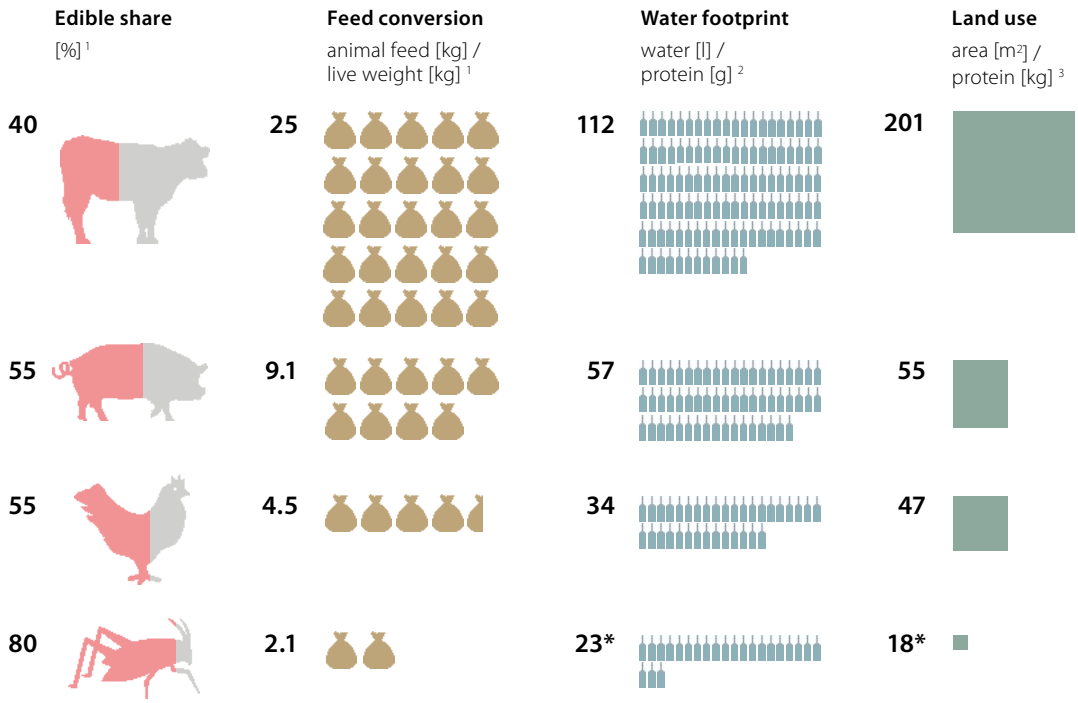

Fig. 1: Ressources needed for each produce: (1) van Huis 2013, (2) Miglietta et al. 2015, (3) Oonicnx/Boer 2012. Schleunitz/Kirstein [eds.], after van Huis (2013), *data collected for mealworm.

Food safety

Insect species are invertebrates and very distinct from vertebrates. Therefore, the pathogens associated with insects do not pose any risk to humans (Eilenberg et al. 2015). That does not mean that insects cannot become diseased. Insect rearing companies are sometimes confronted with diseases that may have a serious effect on insect colonies. The house cricket, *Acheta domesticus*, for example, is highly susceptible to a densovirus which can decimate commercial rearings of crickets (Szelei et al. 2011). Also, the Korean horn beetle, *Allomyrina dichotoma*, used in Korean medicine, suffers from a viral disease, and became a devastating threat for the insect industry (Lee et al. 2015). However, these viruses are not dangerous to humans; some toxic edible insects are eaten. In southern Africa an edible stinkbug (*Encosternum delegorguei*) is considered a delicacy and analysis indicates good nutritional value. However, they secrete a defence chemical that stains skins, and stings eyes such that it may even cause temporary blindness. Some ethnic groups use a method in which water is used to remove the chemical before they consume the insects. In Malawi, this water is afterwards used as a termiticide (Dzerefos et al. 2013).

Problems may arise if insects are not properly processed. For example, the mopane caterpillar, very popular food in southern Africa, is collected, cooked in water, and then dried on the soil by the sun. However, they may pick up pathogens when dried on the bare soil. When insects are commercially reared, hygienic conditions during production are important as contamination is the main food safety risk. There is, however, a risk for people allergic to house dust mite and seafood. Because insects and crustaceans are taxonomically very close, cross reactivity may occur. Even processing, such as an heating step, does not eliminate that risk, as has been shown for three mealworm species (van Broekhoven et al. 2016). This is why insect products should indicate this risk on the label. If insects are reared on organic side streams, then there may be a risk if it contains biological or chemical contaminants. Therefore, certified clean organic by-products should be used.

Insects as feed

For fish, pigs, and chickens insects are natural feed. In the tropics local farmers collect whole or pieces of termite hills and break them in order to feed their chickens, chicks, or guinea fowls. In Asia you often see night lights above ponds in order to attract insects which fall into the water as fish feed. Nowadays, there are companies that produce tonnes of insects a week as feed for animals. Most popular is the black soldier fly (*Hermetia illucens*), which naturally occurs in manure and can easily be grown on organic side streams (Tschirner/Simon 2015). It is used as fish feed and pet food. If it would be used for pigs and poultry, then we are talking

about more than 70% of the feed for animals used in the world, and this market represents more than US$ 300 billion (Alltech 2016). However, in the European Union, the black soldier fly is not yet allowed as feed for pigs and chicken. This was due to the incidence of the mad cow disease, after which it was decided that animals were not allowed to be fed to animals. However, nobody realized at that time that insects are also animals. It is extremely unlikely that insects would pose a threat – in particular when certified clean substrates are used, which do not contain remains of ruminants.

Insect products

In several tropical countries there has been experimenting with insect products (Fig. 2). For example in Mexico, tortillas supplemented with 7% yellow mealworm (*Tenebrio molitor*) larvae powder had excellent consumer acceptance (Aguilar-Miranda et al. 2002). The powder contained 58% protein, rich in essential amino acids, such as phenylalanine, tyrosine, tryptophan, and high contents of the fatty acids oleic acid and linoleic acid. In Korea, muffins containing up to 8% mealworm powder had acceptable sensory properties, such as flavour, taste, and overall acceptability (Hwang/Choi 2015). In Kenya, ground edible winged termites (*Macrotermes subhylanus*) were incorporated in baked food products. Wheat-termite buns at 5% substitution were well accepted by consumers with no difference with the control for texture, aroma, taste, and overall consumer preference (Kinyuru et al. 2009). The 5% substitution showed a significant increase in protein, retinol, riboflavin, iron, and zinc contents. In the Democratic Republic of Congo, a cereal was made from caterpillars in order to study whether it could reduce stunting and anaemia in infants (Bauserman et al. 2015). Stunting was not reduced but infants in the cereal group had higher hemoglobin concentration than infants in the control group and fewer were anaemic.

In the western world the interest in edible insects is also growing. Most popular are different cricket species, in particular the house cricket and several mealworm species which are larvae of beetles that naturally occur in stored grains. The insects can be bought as a whole, often freeze dried. However, mostly the insects are processed into flour and then incorporated in products. The products are protein bars, cookies, and pasta. But they can also be incorporated into familiar products such as burgers, schnitzels, meatballs, and nuggets. In some countries like Belgium and The Netherlands they can be bought as such in the supermarket.

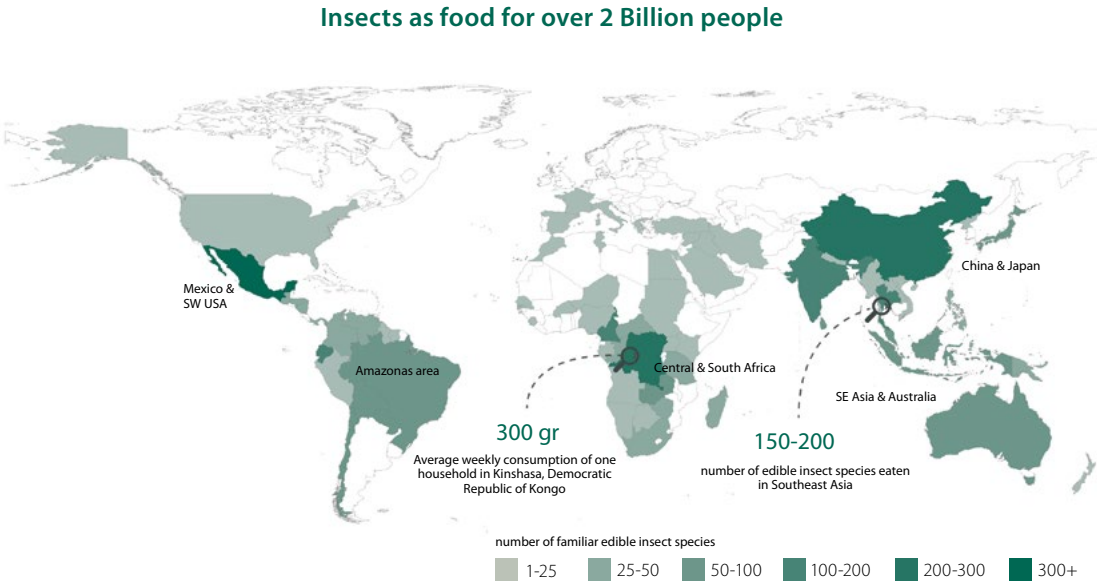

Fig. 2: Familiar edible insect species worlwide, after Jongema (2014)

How to convince consumers?

There are a number of strategies that have been proposed to increase consumer acceptance. The most important one is to incorporate the grinded insect into familiar products such as burgers, muffins, etc. as mentioned above. Another strategy are the so-called 'bug banquets' in which the consumer has the possibility to taste the product and become familiar with it (Looy/Wood 2006). These events are often organized during food fairs. It is of course important to provide information and stress food safety, nutrition, and environmental benefits. Role models are important, e.g. in *The Insect Cookbook* an interview was incorporated with the former secretary-general of the United Nations, Kofi Annan, who indicated that consumer acceptance is just a question of education (van Huis et al. 2014). In the same book there was an interview with René Redzepi, whose restaurant NOMA, was voted to be the best restaurant in the world from 2010 to 2012. He believes it is a "racial thing" that western people do not consider eating insects, because it is from cultures in developing countries; a primitive habit. To convince consumers, it is also important to stress the proximity with crustaceans. For example, edible locusts have been called 'sky prawns' in Australia.

Conclusion

Eating insects is a new concept in the western world, and in order to promote it, the cooperation between disciplines, such as food and nutrition, entomology, agriculture, environmental science, and consumer science, is needed. Because the

topic has been neglected for so long, more information need to be collected of how insects are harvested, prepared, consumed, and marketed in tropical countries. Also, the information in agricultural and food databases is notoriously absent. Recently, FAO/INFOODS collected and published analytical data from primary sources with sufficient quality in the Food Composition Database for Biodiversity (INFOODS 2012). There is still quite some work to do to determine the nutritional value of the 2000 insect species that are eaten. Considering the environmental impact of farming edible insect species, we only have information about mealworm production (Oonincx/de Boer 2012), that is why more studies are urgently needed. In particular, the rearing of edible insect species on organic side streams is interesting and may contribute to achieving a more circular economy. Of course, then, the study of food safety need to be considered, in particular how insects deal with biological and chemical contaminants. The private companies are currently investigating how to automate the production process in order to reduce the cost price. However, all this is not enough. In order to convince the consumer, insects should be made delicious, and this is an important challenge for the cooking industry.

Insects have a lot of potential in food and feed production. It is on its way to become a new agricultural and food sector. Despite the recent interest in this topic worldwide, we are still at a preliminary stage and a lot of effort is needed, by private and public partners, to realize its potential.

Photo by Jens Kirstein

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