Czech University of Life Sciences in Prague

Faculty of Tropical AgriSciences

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Insect as an Alternative Source of Animal Protein in Southeast Asia

Bachelor's thesis

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Thesis supervisor:

Ing. Iva Kučerová, Ph.D.

Elaborated by:

Petra Svobodová

Declaration

I, Petra Svobodová, declare that I have elaborated my thesis “Insect as an Alternative Source of Animal Protein in Southeast Asia“ independently and quoted only quotations listed in references.

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Abstract

Human society often perceives insects as annoying creatures, which are good only as food for insectivores. However, insects can also be part of human´s diet. Due to its high nutritional value, it is even very suitable to be consumed. Over 1 900 species of insects are currently consumed worldwide. The objectives, was the investigation of available literature sources and electronic information databases to analyse insects as an alternative source of animal protein in Southeast Asia. This study analysed 62 insect orders and described processing methods of five insect species more detailed, namely red palm weevil, grasshoppers, wasps, crickets and giant water bugs. The result of this study showed that insects have very good nutritional values, which are essential for human diet. Species with the highest protein content were as follows: order Hymenoptera (range 13 – 77 percent of dry matter) and order Hemiptera (range 42 – 74 percent of dry matter), highly depending on life cycle stage. Therefore, high protein content makes insects a suitable alternative source of animal protein. Insects also contain other necessary substances such as high fat, calcium, iron and zinc. The content of these substances is the same as in beef, chicken and even fish. Even the insect farming is more environmentally friendly, less water and feed are consumed, still prevails insects captured from wildlife and then sold in markets.

Keywords: edible insect, protein, human diet, Southeast Asia, nutrition values, insects farm, entomophagy

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1. Introduction

By 2050, nine billion people will probably live on the planet. Areas for agriculture are still expanding. Seas and oceans are over-exploited for hunting. Moreover, because of climate change, the world is struggling with scarcity of water that is needed to produce food (van Huis et al. 2013). Up 70 % of all agricultural land is used for livestock production. In the future, the demand for livestock products will continue to increase. Therefore, innovative solutions are needed. Insect farming has been suggested as a good alternative to conventional livestock farming for future food production (Jansson & Berggren, 2015).

Land clearing for agriculture is a major contributor to global warming and efficient use of land is therefore important. Insects have a high feed conversion rate, which in a rearing system limits the demand for land for feed production. Moreover, insects emit less greenhouse gases than conventional livestock. It has also been suggested that the volume of water required to produce edible insects is low compared with that needed in conventional livestock production, although empirical data on this are currently lacking (Jansson & Berggren, 2015).

Insects are very nutritious and healthy food source. Edible insects have high content of protein, fat, minerals and vitamins. The content of nutritional values varies with the type of insect. However, even in the same insect species, nutritional values may vary. It depends on the metamorphosis stage of insects, their diet and the environment in which they live. For example, the composition of unsaturatedomega-3 and six fatty acids in mealworms is comparable with that in fish (that is most consumed in Southeast Asia) and the protein,vitamins and mineral content of mealworms is similar to that in fish and meat (van Huis et al., 2013).

Today, edible insect are usually harvested, in the wild and it is only recently that farming of insects for direct human consumption has begun, mainly in Thailand, Laos and Vietnam. In August 2016, a dozen regional insects business owners, met in Bangkok to create AFFIA the Asean Food as Feed Insects Association. The association plans to spread the idea that insects are a viable solution to food shortages, both directly human food, and indirectly as animal feed.

2. Objectives

Objective of this thesis was the investigation of available literature sources and electronic information databases to analyse insect as an alternative source of animal protein in Southeast Asia. Specific objective was to describe different edible insect species, map out their amount and analyse the processing methods.

3. Methods

The work was based mainly on online research of alternative animal protein sources in Southeast Asia. A systematic literature review was performed using an electronic search of ScienceDirect, Scopus, Web of Knowledge and Google Scholar. Primary search terms were: “proteins“, “insect“, “human nutrition“, “food processing“.

4. Literature review

4.1 Human diet and sources of protein

Planet earth and human population are struggling increasing volumes of a growing food demand by an ever increasing number of people (van Duinkerken et al., 2012).

Human nutrition deals with the provision of essential nutrients in food that are necessary to support human life and health. Poor nutrition is a chronic problem often linked to poverty, food security or a poor understanding of nutrition and dietary practise. Malnutrition and its consequences are large contributions to deaths and disabilities worldwide. Good nutrition helps children of poverty. The seven major classes of nutrients are carbohydrates, fats, fibre, minerals, proteins, vitamins and water. These nutrient classes are categorized as either macronutrients or micronutrients. The macronutrients are carbohydrates, fats, fibre, proteins and water. The micronutrients are vitamins and minerals. The macronutrients (excluding fibre and water) provide structural material (amino acids from which proteins are built, and lipids from which cell membranes and some signalling molecules are built), and energy (WHO, 2013).

About 20 percent of the human body is made up of protein. Because human body does not store protein, it is important to get enough from human diet each day. In total, there are around 20 amino acids which the human body uses to build proteins (alamine, arginine, asparangines, asparatic acid, cysteine, glutamine, glutamic acid, glycine, hustidine, isoleucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptohan, tyrosine, valine). These amino acids are classified as either essential or non-essential. Human body can produce non-essential amino acids. However, it cannot produce essential amino acids, which need to obtaine through human diet. For optimal health, our body needs all the essential amino acids in the right ratios (Brown, 2017).

4.1.1 Protein origin

It is possible to obtain protein from many food sources, including plants and animals. Some people claim that the source of the protein, whether animal or plant, shouldn´t matter. Others suggest that plan protein is superior to animal protein. When eaten, protein is broken down into amino acids. Proteins and amino acids are used for almost every metabolic process in the body. However, different proteins can very greatly in the types of amino acids they contain. While animal proteins tend to contain a good balance of all the amino acids that we need, some plant proteins are low in certain amino acids. For example, some key plant proteins are often low in methionine, tryptophan, lysine and isoleucine (Brown, 2017).

Animal protein sources, such as meat, fish, poultry, eggs, dairy are similar to the protein found in human body (Brown, 2017).

These are considered as complete sources of protein because they contain all of the essential amino acids that human body needs to function effectively. On the contrary, plant protein sources, such as beans, lentils and nuts are considered to be incomplete, as they lack one or more of the essential amino acids that our body needs (Hoffman & Falvo, 2004).

Some sources report soy protein as complete. However, two essential amino acids are only found in small amounts in soy, so it is not comparable to animal protein (M. Friedman & Brandon, 2001).

Animal protein sources are higher in certain nutrients, such as vitamin B12, vitamin D, the omega-3 fatty acid DHA, heme-iron and zinc. Of course there are also plenty of nutrients found in plants that are lacking animal food. Therefore, eating balances amounts of both is the best way to get all the nutrients the human body needs (Brown, 2017).

4.1.2 Food security and enviroment

Conventional livestock and fish fading is self-sufficient in the economy due to high demand and productivity, but only for a short time. However, this leads to high environmental costs (van Huis et al., 2013).

For example, manure pollutes water with nutrients. Water is contaminated with toxins and pathogens (van Huis et al., 2013; Thorne, 2007).

The ammonia is contained in the manure, which gets into environment and is not suitable for natural ecosystems. Because it acidifies the environment. In the future, livestock production is expected to grow and therefore higher feed consumption. Agricultural land will expands and deforestation will increase. For example, Amazon has transformed up to 20 % of previously wooded land into pastures. And the feed is grown on much of the rest (Steinfeld et al., 2006).

Agricultural is one of the main reasons for anthropogenic climate change. The world needs other agricultural technologies that will not destroy a planet. Sustainable agriculture and healthier and sustainable diets are appropriate. Humans need to look for alternative sources of protein. For example, beans, fungi, seaweed and/or insects (van Huis et al., 2013).

4.2 Insect

In Latin insects are referred to as insectum. An insect is in translation "with a notched or divided body". Literally translated "cut into sections". The insect has been given this name because the insect body consist of three parts. Pliny the Elder created a word from the Greek word (entomos) or insect (as in enthomology, which was Aristotle´s them for this class of life) because of their notch bodies. The term was first appeared in English in 1601 in Holland´s translation of Pliny (Harpe & McCormack, 2001).

Insect belongs to a group of arthropods. Generally, it has a chitin exoskeleton, a three-part body (head, thorax and abdomen), three parts of jointed legs, compound eyes and two antennae. Insect is one of the most diverse animal groups in the world. More than 1 million species are described on the planet and more than half of all living organism are described. In total, around 6 – 10 million species could be found in the world. Insects potentially contain up to 90 % of all different animal forms. Insect can be found on the entire planet and in almost all environments. A small number of species also live in seas and oceans. They are crustaceans. Insects represent the largest proportion of biodiversity and yet are least studied (van Huis et al., 2013).

More than 1 900 species of insects are destined for human consumption (van Huis et al., 2013).

Insects have a several metamorphic stages than they develop in an adult individual. Insect has two types of reproduction. Perfect reproduction – when the eggs are hatched by larvae that will later become entrapped and hatched by an adult individual. Second type is unperfect reproduction – when the nymph hatches out of the egg and it is stripped several times until it develops in an adult individual. The bees, ants, twins, beetles, butterflies, caddis, fleas, networms and sickles are perfectly reproduction (van Huis et al., 2013).

Figure 1. shows the metamorphosis stages (larvae, pupae and adult beetle) of the Superworms (*Zophobas morio*).

Figure 1.: Morphological stage (larvae, pupae and adult beetle) of the Superworms (*Zophobas morio*) (photo by Petra Svobodová).

4.2.1 Entomophagy

The practise of consuming insects is called entomophagy, from Greek entomon, insect and "phagein", to eat (Jansson & Berggen, 2015).

There is very little doubt that entomophagy can be an important solution in decreasing malnutrition in developing countries, but it may also help to improve health in Western societies. As insects are high in mono- and poly- unsaturated fatty acids, intake of insect products instead of conventional livestock products may have positive health effects. Iron deficiency is the world´s most common nutritional disorder, according to the World Health Organisation (WHO). This condition not only occurs in developing countries but also in Western societies, e.g. in Sweden, 45 % of adolescent girls are at risk of iron content (Bukkens, 1997; Bukkens, 2005; Oonicx et al., 2011), even higher than red meat (FAO, 2013), and entomophagy could therefore be recommended from that perspective (Jansson & Berggen, 2015).

The idea that people resort to eating insects because of hunger is an erroneous western perception as insects are often considered a delicacy in their country of origin. One question is why insects are not consumed in the western world compared to the tropics. Insects are “cold-blooded“animals and most tropical insect species are larger than those living in cold and temperate climates. In addition, tropical regions have higher insect species diversity and mostly edible insect species can be found year-round. This is not the case in cold and temperate regions where insect populations cease developing under cold conditions and hibernate. Another reason is that they normally do not occur in enormous masses, for example, locust swarms. People in cold temperate zones also lives less in and with nature compared to tropical region (FAO, 2012).

The western attitude that eating insects is primitive or a barbarity has not encouraged developing countries to place it high on the agenda of development assistance, even if the tropic crosses though many disciplines (e.g. nutrition, natural resource management, livelihood development). Consequently, western donors have neglected as a possible food source (FAO, 2014).

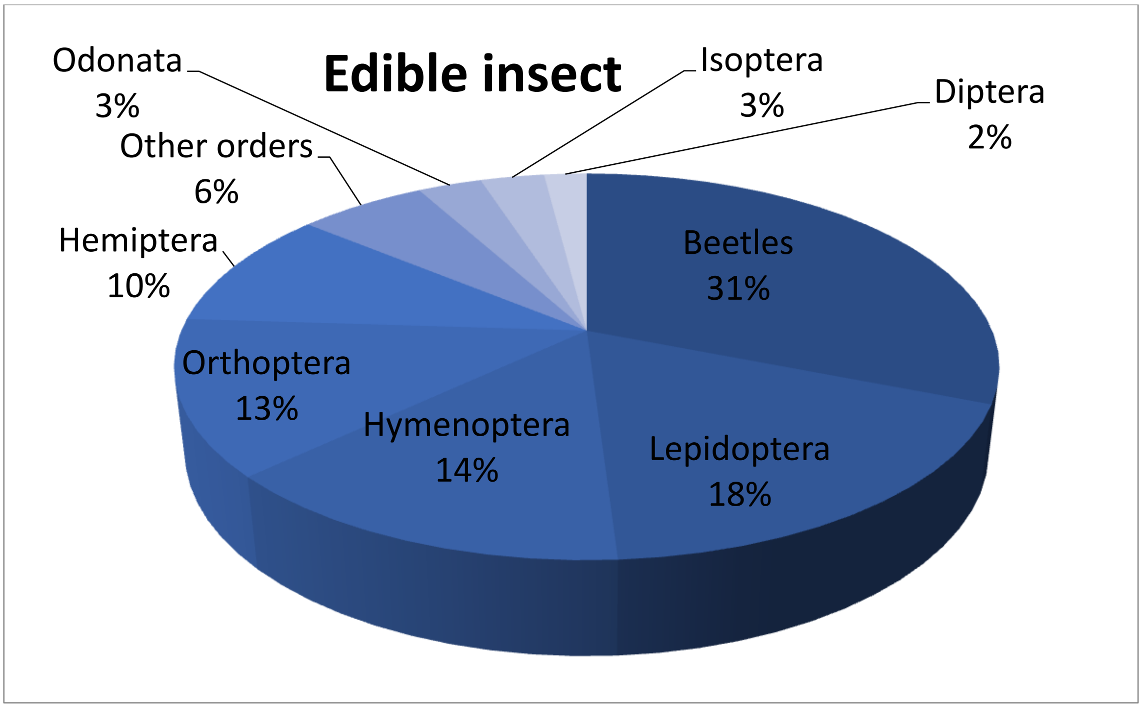
In the last years and through the advocacy of institutions, individuals and the private sector, insects as a food source have seen increased attention by media and policy makers considering insects as an option in order to ensure food security and improve resilience (FAO, 2014).

Traditional foods are those that are consumed in a particular area of community. They are grown and reared or harvested and hunted from nature in the specific area. For example, Indonesia is known as a country that has a diversity of amazing food. Each country has a different regional food. People from Latin America, Africa and Asia consume insects as a part of their diet. Insects are in their diet often for two reasons. Either they do not have enough animal protein from fish, chickens or cattle because they are not available, or the consume insects as a delicacy and for increasing diversity of the diet (FAO, 2012).

4.2.1.1 Edible insect classification

The protein values of edible insect are different. Of course, because of the large number of species, but also in the same group of one species, the values differ. Values depend on the diet, the environment of the individual and metamorphosis phase (manily in insects with complete metamorphosis – known as holometabolous species – bees, ants and beetles). Nutritional values also depend on the preparation of insects as food (e.g. frying, cooking and drying). A few studies analyse the nutritional values of edible insects, but these data are not always comparable due to above – mentioned variants (van Huis et al., 2013).

The graph 1. shows the percentages of edible insects in the world.



Graph 1.: Percentages of edible insects in the world (Cerritos, 2009).

4.2.1.2 The nutritional values

The nutritional value of insects does not differ from the nutritional value of other meat sources such as chicken, beef, pork and fish. In fact, protein levels are often higher in insects and crude protein content in many species as above 60 %. The chitin exoskeleton comprises only a small part of the total biomass (< 10 %) and can even be digested. Chitinase is contained in human gastric juice. It has been shown that chitin has even complex and size-depended effects on innate and adaptive immune responses (van Huis et al., 2013).

The results of studies dealing with nutritional values of edible insects are not always comparable. Mainly because of the number of insects species and various methods used to analyse compounds. The edible insect is only part of food in the countries where it is consumed, and it can be different. Because of their high nutritional value, they are very good source of food for human (van Huis et al., 2013).

Important insect components are dietary energy, proteins, fat, fibres, fatty acids, minerals and vitamins. Rumpold and Schluter (2013) have created a nutritional composition for 236 species of edible insects. As mentioned above, the data showed significant difference, but is important the insects contained sufficient nutritional values. Insects contain high amounts of monounsaturated and/or polyunsaturated fatty acids and contain many macronutrients such as manganese, iron, copper, magnesium, selenium, zinc and phosphorous, as well as pantothenic acid, riboflavin, biotin and sometimes folic acid (van Huis et al., 2013).

4.2.1.2.1 Dietary energy

Ramos Elorduy et al. (1997) explored 78 insect species from Oxaca in Mexico. They found the amount of energy was 293 – 762 kilocalories per 100 grams of dry matter. The amount of kilocalories also depends on the diet of insect. Table 1. shows example of energy content id different insect species by Thailand.

Table 1: Example of energy content in different edible insect species by Thailand (Huis et al., 2013)

Common name	Scientific name	Energy content (kcal/100 g fresh weight)
Field cricket, raw	*Gryllus bimaculatus*	120

Giant water bug, raw	*Lethocerus indicus*	165
Rice grasshopper, raw	*Oxya japonica*	149
Grasshopper, raw	*Cyrtacanthacris tatarica*	89
Domesticated silkworm, raw	*Bombyx mori*	94

4.2.1.2.2 Protein

Protein is very important for human. It contributes to sensory and physical properties. Intake of protein and its nutritional value is dependent on the content of food, its digestibility and protein quality, which depends on the kind of amino acid. Amino acids are divided into essential and nonessential group. Essential amino acids are indispensable, because the human body can not produce them and only have to obtain them from food. Eight amino acids are included in this group: threonine, tryptophan, methionine, isoleucine, leucine, phenylalanine, valine and lysine. Proteins form an organic amino acid compound. Amino acids are basic building blocks for the biosynthesis of all proteins by human metabolism (van Huis et al., 2013).

Xiaoming et al. (2010) evaluated the protein content of 100 species from a number of insects orders. Table 2 shows that protein content was in the range 13 – 77 percent of dry matter and that these were large variation between and within insects orders.

Table 2: Protein content, by insect order (Huis et al., 2013)

Insect order	Metamophosis stage	Range (% protein)
Coleoptera	Adults and larvae	23 – 66
Lepidoptera	Pupae and larvae	14 – 68
Hemiptera	Adults and larvae	42 – 74
Homoptera	Adults, larvae and eggs	45 – 57
Hymenoptera	All stadies	13 – 77
Odonata	Adults and naiad	46 – 65
Orthoptera	Adults and nymph	23 - 65

Insects have a high protein and therefore their use as a food for humans can play a large role in the representation of animal protein. However, all insect species do not have the same protein content. Some species have more protein and can be compared with fish or mammals. The protein content also depends on the metamorphosis stage of the individual (adults usually have highest protein content) and their diet (vegetables, granules) (van Huis et al., 2013).

Cereals ensure the need for proteins around the world. Some cereals lack some important amino acids tryptophan and threonine, and some cereals do not have lysine. Some insect species contain these important ingredients (van Huis et al., 2013).

Insects can be included in human nutrition as food. However, traditional foods and their nutritional values have to be taken into account compared with the nutritional value of insects in the locality. For example, people in Papua New Guinea consume tubers that contain tryptophan and aromatic amino acids but contain little lysine and leucine. The low content of lysine and leucine is replaced by consumption of red palm weevil, which is rich in these amino acids (van Huis et al., 2013).

4.2.1.2.3 Fat content

Fat supplies the human body with energy. In food, fat is very important. Fats are composed of triglycerides that contain a glycerol and three fatty acids. Saturated fatty acids are also in tropical plant (e.g. coconut and palm oil) and animal products (e.g. sausages, bitter, lard). Saturated fatty acids have a higher melting point than unsaturated fatty acids and are solid at normal temperature. Unsaturated fatty acids are liquid at normal temperature. They are composed of mono-unsaturated fatty acids and poly-unsaturated fatty acids. They are in vegetable oil, seafood and nuts. They supply less energy to the human body than saturated fatty acids, but are considered better for human health (van Huis et al., 2013).

Essential fatty acids must be obtained from the food, because the human body can not synthesize them. Some omega-6 fatty acids and some omega-3 fatty acids are included in this group (van Huis et al., 2013).

Therefore, the most important are the unsaturated fatty acids and essential fatty acids for the human body. Especially for infants and children, are important poly-unsaturated fatty acids and essential linoleic and alfa-linoleic acids. It has been shown insect bodies contain these fatty acids and their consumption in advantageous for the human body (van Huis et al., 2013).

The content and composition of fatty acids in insects is greatly influenced by their diet (Bukkens, 2005).

4.2.1.2.4 Micronutrients

Minerals and vitamins important to the human body are included in the micronutrients. Their absence in human diet, mainly in developing countries, has a detrimental effect on human development, the immune system, reproduction and overall health (FAO, 2011).

The content of all micronutrient depends largely on the diet of the individual, the type of insect and their metamorphoses stage. The content of minerals and vitamins is also affected and dependent if the individual consumes whole body or part of it. Slender results are also expected in insects, when eating the whole body of insects will have better results in terms of micronutrients. For these reasons, the micronutrients content of the literature is very diverse and the values differ more than other nutrients (van Huis et al., 2013).

Minerals

Minerals are necessary nutrients for the human body, which the body can not create itself and must obtain them from food and water. The recommended dietary allowance (RDA) is the term used for individual daily intakes of nutrients, which is considered to be sufficient to cover the need for most healthy individuals (Bukkens, 2005).

One of the important minerals, which the human body needs, is iron. According to World Health Organisation (WHO), iron deficiency worldwide is a widespread disorder. The most sufferers from iron deficiency are people in the developing countries. Up to 20 percent of preschool children, and many pregnant women suffers from anaemia. The anemia is a condition, when the haemoglobin is reduced in the blood and the ability of the blood to supply oxygen to the tissues is reduced. This is a disrupted physical development of the individual and increased mortality of children. Fatigue, tiredness and headache often occurs. Edible insect has a high iron content and they are therefore offered as a suitable solution (van Huis et al., 2013).

Vitamins

Vitamins, as well as minerals, the human body can not produce and must obtain it from food. In the human body are important as catalysts of biochemical reactions and contribute to the metabolic of sugars, fats and proteins. Edible insects are also rich in important vitamins. For example, vitamin B1 (thiamine), which is favourable for the nervous system and fatigue, is contained in the insects in the range of 0,1 – 4 mg/100 g of dry matter. Or vitamin B2 (riboflavin), which is important in the body for good condition of the skin, eyes, heart function and other organs, is contained in the insects in the range of 0,11 – 8,9 mg/100 g of dry matter. But vitamin B12 (cobalamin) is abundantly represented in some species of edible insects (e.g. mealworm larvae, house cricket, *Acheta domesticus*). The edible insects are not yet sufficiently researched to evaluate all the results of the vitamin B content in their bodies (Bukkens, 2005; van Huis et al., 2013).

4.2.1.2.5 Fibre

Fibre is important mainly because of energy supply and as "brush" of the intestines, which prevents bowel disease (e.g. colon cancer). In the insect body is contained the fibre in chitin. Chitin is an insoluble fibre found in the exoskeleton. The amount of fibre has been calculated in various ways and its therefore not entirely comparable (van Huis et al., 2013).

However, by Finke (2007) concept who tested insect as food for insectivores, the fibre content ranged from 2.7 – 49.8 mg/1 kg (fresh). Chitin is a long-chain polymer of n-acetylglucosamine – a derivative of glucose. After polysaccharide cellulose that resembles it, chitin is the most widespread polymer on the Earth. Chitin has been also associated with defence against parasitic infections and some allergic conditions (van Huis et al., 2013).

The high fibre content has mainly insects with hard exoskeleton, which contain a large amount of chitin (Bukkens, 2005).

4.2.2. Collecting insects from the wild

Insect have in nature many functions. It can serve as a feed, as an effective pollinators, parazit can be used as a biological weapon against pests or as decomposers that decompose the plant and animal remains in nature (Losey & Vaughan, 2006).

Edible insects (e.g. bees, ants and beetles) also participate in these biological processes and therefore they are an integral part of the ecosystem. Insects have always been taken as an inexhaustible source. However, until recently, when insects become threatened species (van Huis et al., 2013).

Some insect species are more safe than the others. Nevertheless, each species has its role in the nature and amount of some insect species are fluctuating. The problem is that collecting insects from the wild can interfere with the natural balance (van Huis et al., 2013).

Most edible insects serve as food for other animals (frogs, spiders, birds, mammals, reptiles, amphibian and fish), and if the number of insects in nature is reduced rapidly due to collection for humans, it could have great consequences in the wildlife. The reduction in insects did not imply a negative impact on predators, but the long-term reduction of insects as feed for predators could have adverse consequences for their loss of food. Reducing the number of insects in some species could also negatively affect insect species, because some insects are also predators for other insects. Negative impact could also have on the whole ecosystem, which is strongly threated by any change. Excessive collection of edible insects from nature is therefore another problem of current and future entomophagy (van Huis et al., 2013).

In addition, if the recovered capacity exceeds the number of harvested insects, insects can not normally reproduce (van Huis et al., 2013).

Then the insect populations, which are collected at any stage of life, are in the risk (Illgner & Nel, 2000; Latham, 2003; Ramos Elorduy & Pino, 2006).

This means, for example, that there could be lack of insect females for laying down eggs or individuals who are able to mate (van Huis et al., 2013).

For example, in the Lao People´s Democratic Republic in village of Dong Makkhai edible insects are sold in market Sahakone Dan Xang. There are 21 species of edible insects sold, and only 23% of these species are from domestic breed. It that the most of the insects sold on the market comes from the wild. The most common are grasshoppers, ant eggs (larvae and pupae of *Oecophylla smaragdia*), crickets (*Tarbinskiellus portentosus, Acheta domesticus* and *Teleogryllus mitratus*), cicadas (Orientopsaltria spp.) and waps (Vespa spp.). At present time, collectors say that collecting of insect is more problematic. It takes more time to collect the same amount of insects comparing with time a decade ago (van Huis et al., 2013).

It would be desirable to start to raise insect the same way as the farm livestock and do not harvest them only from the wild. Even there is a plenty of insect in the world, the human can not take it as an inexhaustible source of food (van Huis et al., 2013).

4.2.2.1 Farming

Consuming insects has a number of advantages. As is clear from the previous chapter, insects will not be an appropriate alternative if they are only collected from the wild. In order to make good use of its potential, insects must behave in the same way as livestock in a conventional manner. Insect breeding and rearing is more environmentally friendly because it produces less greenhouse gases and ammonia. It can be kept on organic residues, which removes the waste from nature. Insects consume water mainly from food, therefore it needs substantially less water (1 kg of beef requires 22 000 litres of virtual water) (van Huis et al., 2013).

Even in term of feed, insects are better. For example, a cricket (*Acheta domesticus*) consumes up to six less food than cattle, calculated to produce the same amount of animal protein. Insects have not yet been scientifically proven to be able to feel pain as other animals. It is likely that insects are smaller zoonos transporters than other animals. Therefore, insects are a potential source of convention production (mini-livestock) of protein, either for direct human consumption, or indirectly in recomposed foods (with extracted protein from insects), and as a protein source into feedstock mixtures (FAO, 2012).

It is advisable to breed insects that are typical of the local ecosystem and climate in order to create the most suitable conditions for breeding and to minimize the risks to the local area in the event of insect leakage. And it is advisable to breed species of insects that are easy to breed and the tasty and nutritious for humans (van Huis et al., 2013).

4.3 Entomophagy in Southeast Asia

It is estimated that insects are included in the diet over two billion people around the world, and nowadays as food is consumed over 1 900 species of insects (FAO, 2013).

150 – 200 species of insects for human consumption was decribed in Southeast Asia. Due to migration of people, entomophagy came almost to all parts of the Asian countries where entomophagy was not previously practised. For example, in Thailand, entomophagy was a normal part of the human diet in northeaster Thailand, and thanks to migrations of people, it was spread over the whole country. Even, in the capital city Bangkok, there is now the largest number of edible insects in the whole country (81 species of edible insect), by the fact that Bangkok is a very popular tourist destination and tourist eat insects as part of exotic experience (Yen, 2009).

Entomophagy is almost everywhere part of the people´s diet in Southeast Asia. Insect very often insects appear on traditional local markets for fresh food. Insect is often referred to as a delicacy, but rarely, edible insects are a constant source of food as an alternative to normal food. Some people even think that consuming of insect is disgusting.

Table 3 shows the reasons why insects are consumed in Thailand.

Table 3: Reasons given for eating insects in Thailand (Hanboonsong et al., 2000)

Reasons for eating edible insects	Amount of respondents (%)
Tasty	75
Snack	65
Use as ingredients in cooked meals	48
Traditional medicine	48
As food seasoning	32
Easy to find around the farm	30
Readily available food	22

Accessible for mass production	19
Cultural eating	9
Seasonal food source	2
Local food source	2
Pest control	0.38

4.3.1 Insect species

Edible insect vary acoording to the species pupolarity and region. Red palm weevils (*Rhynchophorus ferrugineus*), which are as a delicacy in SE Asia, are the most often found on the local markets (van Huis et al., 2013).

Some species of insects can be found in nature almost all year round, when others occur only in the season. Especially in Laos, Vietnam, Thailand and Myanmar, where about 164 species of edible insects are found in nature all year round, and people can consume these species and can create insects supplies (Young: Aree & Viwatpanich, 2005).

Table 4 shows the annual availability of selected insect species in Thailand.

Table 4: Availability of edible insects in Thailand by month (Huis at al., 2013)

Month	Types of edible insects
January	Grasshopper, tortoise beetle, skipper
February	Adult red ant, dung beetle, scarab beetle, stink bug
March	Cicada, termites, dung beetle
April	Dung beetle, grasshopper
May	Ground cricket
June	Giant water bug, wood-boring beetle, predaceous diving beetle
July	Back swimmer, crawling water beetle, damselfly, spider
August	wasp, beetle
September	Rhimoceros beetle, spider
October	Cricket

November	Long-horned beetle
December	Mole cricket, river swimmer, true water beetle, water scavenger beetle, water scorpion beetle

In markets in Southeast Asia, edible insects are often sold in modified form (e.g. fried, dried, boiled) with different kinds of spices, chocolate or coconut. Insects are often also served as a supplement. Some insect larvae are also consumed raw. Below are described specimen of edible insect most commonly found in Southeast Asia markets. These types of edible insects are most often and best collected from the wild (van Huis et al., 2013).

Red palm weevil

The palm weevil (*Rhynchophorus ferrungineus*) is one of two species of snout beetle known as the red palm weevil, Asian palm weevil or sago palm weevil. The adult beetles are relatively large, ranging between two and four centimetres long, and are usually a rusty red colour, but many colour variant exist (van Huis et al., 2013).

The weevil is widely found in southern Asia and Melanesia, where they feed palm species, in particular, the most are coconut palm (*Cocos nucifera*), oil palm (*Elaeis guineensis*), date palm (*Phoenix dactylifera*), sago palm (*Metroxylon sagu*) and Raphia palm (Raphia spp.). In some areas within this region it has also been recorded as a serious pest of introduced palms, particularly coconut (Kalshoven, 1981; Rajamanickam et al., 1995).

This weevil usually infects palms younger than twenty years. While the adult caused some damage through feeding, it is burrowing of the palm that can cause the greatest mortality of trees. Females lay a several hundred egg in the palm trunk of the palm or on the new leaves. When the larvae hatch, they attack the heart of the palm tree and palm will die. The egg hatches into a white, legless larva. The larva will feed on the soft fibres and terminal buds, tunnelling through the internal tissue of the tree for about a month. A fully extended larva measures, on average, 10.5 cm in length and 5.5 cm in width and weights 6.7 grams. At pupation, the larva will leave the tree and form a cocoon built of dry palm fibres in leaf litter at the base of the tree. On average, the larvae live for seven to ten weeks. Collecting the larvae from the palm is both time consuming and physically demanding. Therefore, larvae are often collected only by men (van Huis et al., 2013).

Figure 2. shows how the red palm weevil larvae are most commonly consumed. The raw larva is sprinkled on a spit and battens over the fire.

Figure 2.: Fried red palm weevil larvae (*Rhynchophorus ferrugineus*) on the stick, Thailand (photo by Globalfoodbook).

Fried Grasshoppers

Gurung Kidul in the south of Yogyakarta also offers fried grasshoppers which are sold as a snack. The fried grasshoppers are available in original, hot and sweet-hot flavours. For the first-timers, original flavours are recommended. This snack is believed to contain vitamin A and proteins. Other insects such as crickets, moths and ungkrung (cocoon) are also offered as chips (Ruggerini et al., 2014).

Fried crickets

Thailand is accustomed to sell fried crickets, as sometimes it happens in Indonesia. In the area of Ciamis, West Java, people crickets became very typical. They are fried and then spiced up (Ruggerini et al., 2014).

Wasps

Wasps are often found in East Java. Farmers do not discard the rest of the harvest usually inhabited by wasp larvae. They will process the wasp to be a culinary delight, the Batok wasps filing, with spices and coconut. Since it is believed that insects have high protein content, they began to be used as food in some areas in Indonesia. Some are used as a side dish and some are prepared as snacks (Ruggerini et al., 2014).

Giant water bug

Giant water bug is another popular type of insect to consume. Most often, giant water bug is collected from the wild. People collect collecting devices called black light to collect them. Bugs are captured and collected. After collection, the life bugs are immediately processed. The most common way of preparation is frying and grilling over the fire, then they are peeled out and used for meals. It is not possible to eat the giant water bug whole. Many tourists buy a bug and want to taste an exotic delicacy, but they don´t know how to eat it. It is necessary to remove the hard wings and the exoskeleton. A variety of species and herbs (basil leaf, chilli, lemon grass and garlic) is used to improve the taste ant the odour of insects (Hanboonsong, 2010).

Table 5. shows edible insect in Southeast Asia and protein content in the range percent of dry matter by insect genus.

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Araneus sp.	n.a.	*Araneidae*	Indonesia	Adult	n.a.	Fried	Healy and Florey, 2003
Nephila	n.a.	*Nephilidae*	Thailand	Adult	n.a.	Fried	Bristowe, 1932
Nephila	n.a.	*Nephilidae*	Thailand	Adult	n.a.	Fried	Bristowe, 1932
Haplopelma	Thai zebra tarantula	*Theraphosidae*	Cambodia	Adult	n.a.	Fried	Yen et al., 2013
Haplopelma sp.	Spider	*Theraphosidae*	Laos	Adult	n.a.	Fried	Young-Aree et al., 2005
Heteropodidae gen.	Huntsman spider	*Heteropodidae*	Indonesia	Adult	n.a.	Fried	Healey and Florey, 2003
Melopoaeus sp.	Spider	*Theraphosidae*	Laos	Adult	n.a.	Fried	Young-Aree et al., 2005
Buprestis sp.	Jewel beetle	*Buprestidae*	Thailand	Adult	42-74	Fresh	DeFoliart, 2002
Chrysochroa sp.	Flat heads apple borer	*Buprestidae*	Thailand	Adult, larvae	42-74	Raw, fried	DeFoliart, 2002
Chrysochroa sp.	Jewel beetle	*Buprestidae*	Malaysia, Sabah	Larvae	42-74	Raw, fried	Chung et al., 2002
Stenocera	Jewel beetle	*Buprestidae*	Thailand	Adult	42-74	Raw, fried	DeFoliart, 2002
Stenocera sp.	Jewel beetle	*Beprestidae*	Thailand	Adult	42-74	Raw, fried	DeFoliart, 2002
Aeolesthus sp.	n.a.	*Cerambycidae*	Thailand	Adult	42-74	Raw, fried	Hanboonsong et al., 2000
Apriona	Mulberry longhorn	*Cerambycidae*	Thailand, Vietnam	Adult, larvae	42-74	Raw, fried	Hanboonsong et al., 2000
Aristobia	n.a.	*Cerambycidae*	Thailand	Adult, larvae	42-74	Raw, fried	Hanboonsong, 2010
Batocera	Na.a.	*Cerambycidae*	Indonesia	n.a.	n.a.	n.a.	Meer, v.d. Mohr, 1965

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Batocera	Mango-tree longicorn borer	*Cerambycidae*	Philippines	Larvae	42-74	Raw, fried	DeFoliart, 2002
Batocera	n.a.	*Cerambycidae*	Indonesia	Larvae	42-74	Raw, fried	DeFoliart, 2002
Batocera	n.a.	*Cerambycidae*	Indonesia	n.a.	n.a.	n.a.	Roepke, 1951
Batocera sp.	n.a.	*Cerambycidae*	Indonesia	Larvae	n.a.	Raw, fried	Chung, 2003
Dorysthenes	n.a.	*Cerambycidae*	Thailand	Adult	42-74	Raw, fried	Hamboonsong, 2010
Hoplocerambyx	Sal heartwood borer	*Cerambycidae*	Malaysia	Larvae	42-74	Raw, fried	DeFoliart, 2002
Macrotoma	n.a.	*Cerambycidae*	Thailand	Adult	42-74	Raw, fried	Utsunomiyia and Masumoto, 1999
Macromota sp.	n.a.	*Cerambycidae*	Malaysia	Larvae	42-74	Raw, fried	Chung et al., 2002
Neoplocaederus	n.a.	*Cerambycidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Plocaderus syn.	n.a.	*Cerambycidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong, 2010
Rhaphipodus sp.	n.a.	*Cerambycidae*	Malaysia, Sabah	Larvae	42-74	Raw, fried	Chung et al., 2002
Threnetica	n.a.	*Cerambycidae*	Laos	n.a.	42-74	n.a.	Young-Aree et al., 2005
Aplosonyx	n.a.	*Chrysomelidae*	Malaysia, Sabah	Larvae	42-74	Raw, fried	Chung et al., 2002
Sagra	n.a.	*Chrysomelidae*	Laos	n.a.	42-74	n.a.	Young-Aree et al., 2005
Arrhines	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Arrhines sp.	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Astycus	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Cnaphoscapus	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	Hamboosong, 2010

Table 5.: Edible insect in Southeast Asia

Latin name	**Common name**	**Family**	**Distribution**	**Life stages**	**Range - % protein**	**Consumption**	**References**
Episomus	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong, 2010
Episomus sp.	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong, 2010
Hypodisa	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	DeFoliart, 2002
Hypomeces	Gold dust weevil	*Curulionidae*	Thailand	Adult	42-74	Raw, fried	DeFoliart, 2002
Pachyrrhynchus	n.a.	*Curulionidae*	Philippines	Adult	42-74	Raw, fried	DeFoliart, 2002
Pollendera	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Sitophilus	n.a.	*Curulionidae*	Whole region	All stages	42-74	Raw, fried	Taylor, 1975
Tanymecus sp.	n.a.	*Curulionidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Cyrtotrachelus	n.a.	*Dryophthoridae*	Thailand	Adult	42-74	n.a.	Utsonomia and Masumoto, 1999
Protocerius sp.	Giant weevil	*Dryophthoridae*	Indonesia	Larvae	42-74	Raw, fried	Chung, 2010
Rhynchophorus	n.a.	*Dryophthoridae*	Thailand	Adult	42-74	n.a.	Hamboonsong et al., 2000
Rhynchoporus	Red palm weevil	*Dryophthoridae*	Thai., Mal., Ind., Viet.	Adult, Larvae	42-74	Raw, fried	Lukiwati, 2010
Copelatus sp.	n.a.	*Dytiscidae*	Thai., Phil.	n.a.	42-74	n.a.	Hamboonsong et al., 2010
Cybister	n.a.	*Dytiscidae*	Indonesia	n.a.	42-74	n.a.	Ramos et al., 2009
Cybister	Dviving beetle	*Dytiscidae*	Thailand, Laos	Adult, larvae	42-74	n.a.	Hamboonsong et al., 2010
Cybister	Diving beetle	*Dytiscidae*	Indonesia	Adult, larvae	42-74	Raw, fried	Meer, v.d. Mohr, 1995
Cybister sp.	Diving beetle	*Dytiscidae*	Vietnam	Adult	42-74	n.a.	DeFoliart, 2002

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Eretes	Twinpoes diving beetle	*Dytiscidae*	Thailand, Laos	Adult, larvae	42-74	Raw, fried	Hamboonsong et al., 2000
Hydatius	Diving beetle	*Dytiscidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Laccophilus	Diving beetle	*Dytiscidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Rhantaticus	Diving beetle	*Dytiscidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Haliplidae gen.	Crawling waterbeetle	*Haliplidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Hydrobiomorpha	n.a.	*Hydrophilidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Hydrophilus	n.a.	*Hydrophilidae*	Thailand, Vietnam	Adult	42-74	n.a.	Hamboonsong et al., 2000, DeFoliart, 2002
Hydrophilus	n.a.	*Hydrophilidae*	Laos	Adult	42-74	n.a.	Young-Aree et al., 2005
Hydrophilus	Water scavenger b.	*Hydrophilidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Sternopholus	n.a.	*Hydrophilidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Dorcus sp.	n.a.	*Lucanidae*	Malaysia, Sabah	Larvae	42-74	n.a.	Chung et al., 2002
Odontolabis sp.	n.a.	*Lucanidae*	Malaysia, Sabah	Adult, larvae	42-74	Raw, fried	Chung et al., 2002
Odontolabis sp.	n.a.	*Lucanidae*	Indonesia, Kalimantan	Adult, larvae	42-74	Raw, fried	Chung, 2003
Acerainus sp.	n.a.	*Passalidae*	Malaysia, Sabah	Larvae	42-74	Raw, fried	Chung et al., 2002
Adorelus	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Adorestus sp.	n.a.	*Scarabaeidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Agestrata	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hamboonsong et al., 2000

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Latin name	**Common name**	**Family**	**Distribution**	**Life stages**	**Range - % protein**	**Consumption**	**References**
Anomala	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hamboonsong et al., 2000
Apogonia sp.	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Brahmina	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Utsunomiya and Masumoto, 1999
Catharius	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hamboonsong et al., 2000
Chaetadoretus	n.a.	*Scarabaeidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Chalcosoma	n.a.	*Scarabaeidae*	Malaysia, Sabah	Larvae	42-74	Raw, fried	DeFoliart, 2002
Chalcosoma	n.a.	*Scarabaeidae*	Indonesia	Larvae	42-74	Raw, fried	Chung, 2010
Copris (Microcopris)	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hamboonsong et al., 2000
Copris (Paracopris)	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hamboonsong et al., 2000
Copris (s.str.)	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hamboonsong et al., 2000
Copris	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Utsunomiya and Masumoto, 1999
Copris sp.	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Copris sp.	n.a.	*Scarabaeidae*	Laos	Adult	42-74	n.a.	Hamboonsong and Durst, 2014
Empectida	n.a.	*Scarabaeidae*	Thailand	n.a.	42-74	n.a.	Utsunomiya and Masumoto, 1999
Eupatorus	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Utsunomiya and Masumoto, 1999
Exolontha	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Utsunomiya and Masumoto, 1999
Exopholis	n.a.	*Scarabaeidae*	Indonesia	Adult	42-74	n.a.	Meer, v.d. Mohr, 1965
Exopotus sp.	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Gymnoplerus	Dung beetle	*Scarabaeidae*	Laos	n.a.	42-74	n.a.	Young-Aree et al., 2005
Heliocopris	Dung beetle	*Scarabaeidae*	Myanmar	Adult, pupae, larvae	42-74	Raw, fried	DeFoliart, 2002
Heliocopris	Dung beetle	*Scarabaeidae*	Thailand	Adult, pupae, larvae	42-74	Raw, fried	Hamboonsong et al., 2000
Heliocopris	Dung beetle	*Scarabaeidae*	Laos	n.a.	42-74	n.a.	Young-Aree et al., 2005
Heliocopris sp.	Dung beetle	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Heteronychus	n.a.	*Scarabaeidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2000
Holotrichia	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Holotrichia sp.	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hamboonsong, 2010
Holotrichia sp.	n.a.	*Scarabaeidae*	Laos	Adult	42-74	n.a.	Young-Aree et al., 2005
Hoplosternus	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Lepidiota	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Lepidiota	n.a.	*Scarabaeidae*	Philippines	Adult	42-74	n.a.	DeFoliart, 2002
Lepidiota	n.a.	*Scarabaeidae*	Thailand	Adult, larvae	42-74	Raw, fried	DeFoliart, 2002
Lepidiota	n.a.	*Scarabaeidae*	Indonesia	Adult, larvae	42-74	Raw, fried	Chung, 2003
Lepidiota sp.	n.a.	*Scarabaeidae*	Thailand	Adult, larvae	42-74	Raw, fried	DeFoliart, 2002
Leucopholis	n.a.	*Scarabaeidae*	Phil., Indonesia	Adult	42-74	42-74	DeFoliart, 2002
Leucopholis	n.a.	*Scarabaeidae*	Malaysia, Sabah	n.a.	42-74	42-74	Chung et al., 2002
Leucopholis sp.	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	42-74	DeFoliart, 2002

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Liatongus	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Malandera sp.	n.a.	*Scarabaeidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong et al., 2000
Megistophylla	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Melolontha	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Mimela	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Miridibla	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Oniticellus	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Onitis	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Itsonomiya and Masumoto, 1999
Onitis sp.	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Onitis sp.	n.a.	*Scarabaeidae*	Laos	Adult	42-74	n.a.	Hamboonsong and Durst, 2014
Onthophagus	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hanboonsong et al., 2000
Onthophagus sp.	n.a.	*Scarabaeidae*	Thailand	Adult, larvae	42-74	n.a.	DeFoliart, 2002
Oryctes	Asiatic rhinoceros	*Scarabaeidae*	Thailand, Phil., Maynmar	Adult, pupae	42-74	n.a.	DeFoliart, 2002
Pachnessa sp.	n.a.	*Scarabaeidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong et al., 2000
Paragymnopleurus	Beetle	*Scarabaeidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong et al., 2000
Paragymnophurus	Dung beetle	*Scarabaeidae*	Laos	n.a.	42-74	n.a.	Young-Aree et al., 2005
Peltonotus	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Danell, 2010
Polyphylla	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Utsonomiya and Masumoto, 1999
Protateia sp.	n.a.	*Scarabaeidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong et al., 2000

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Protateia sp.	n.a.	*Scarabaeidae*	Indonesia	*n.a.*	42-74	n.a.	Meer, v.d. Mohr, 1965
Psilophidos sp.	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Scaptodera	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hambonnsong et al., 2000
Sophrops	n.a.	*Scarabaeidae*	Thailand	Adult	42-74	n.a.	Hamboonsong et al., 2000, Utsonomiya and Masumoto, 1998
Xylotrupes	n.a.	*Scarabaeidae*	Thailand, Maynmar	Adult, larvae	42-74	Raw, fried	DeFoliart, 2002
Xylotrupes	n.a.	*Scarabaeidae*	Indonesia	Adult, larvae	42-74	Raw, fried	Meer, v.d. Mohr, 1965
Xylotrupes	n.a.	*Scarabaeidae*	Malaysia, Sabah	Adult, larvae	42-74	Raw, fried	Chung et al., 2002
Palembus	Korean bug	*Tenebrionidae*	Philippines	n.a.	42-74	n.a.	Adalta et al., 2010
Tenebrio	Mealworm beetle	*Tenebrionidae*	Laos	Larvae	42-74	Raw, fried	Hamboonsong and Durst, 2014
Panesthia sp.	Jungle cockroach	*Blaberidae*	Malaysia, Sabah	Adult	42-74	Raw, fried	Chung et al., 2002
Blatta	n.a.	*Blaberidae*	Thailand	Adult, egg	42-74	Raw, fried	DeFoliart, 2002
Neostylopyga	Harlequin cockrocach	*Blaberidae*	Thailand	Adult, egg	42-74	Raw, fried	DeFoliart, 2002
Hierodula	n.a.	*Mantidae*	Indonesia	n.a.	n.a.	n.a.	Meer, v.d. Mohr, 1965

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Tenodera sp.	n.a.	*Mantidae*	Malaysia, Sabah	n.a.	n.a.	n.a.	Chung et al., 2002
Hermetia	n.a.	*Stratiomyidae*	Malaysia, Sabah	Larvae	n.a.	n.a.	Chung et al., 2002
Ephemeroptera gen.	n.a.	*Ephemer. fam*	Viet., Ind., Kalimantan	Adult	n.a.	n.a.	DeFoliart, 2002, Chung, 2003
Mantidae gen.	n.a.	*Mantidae*	Indonesia, Kalimantan	n.a.	*n.a.*	n.a.	Chung, 2003
Tenodera	Chinese mantis	*Mantidae*	Thailand, Indonesia	n.a.	*n.a.*	n.a.	Hamboonsong et al., 2000, Meer, v.d. Mohr, 1965
Leptocorisa	Paddy bug	*Alydidae*	Indonesia	n.a.	42-74	Raw, fried	DeFoliart, 2002
Leptocorisa	Rice bug	*Alydidae*	Malaysia, Indonesia	n.a.	42-74	Raw, fried	Chung, 2010
Diplonychus sp.	n.a.	*Belostomatidae*	Thailand	n.a.	42-74	n.a.	Hamboonsong et al., 2010
Lethocerus	Giant water bug	*Belostomatidae*	Thai., Mal., Mya., Viet.	n.a.	42-74	Raw, fried	DeFoliart, 2002
Spharodema	n.a.	*Belostomatidae*	Thailand	n.a.	42-74	n.a.	DeFoliart, 2002
Anoplocnemis	Leef-footed bug	*Coreidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong, 2010
Homoecerus sp.	Stink bug	*Coreidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong et al., 2000
Cylindrostethus	Water strider	*Gerridae*	Thailand	n.a.	42-74	n.a.	Hanboonsong, et al., 2000
Lacotrephes	Water scorpion	*Nepidae*	Thailand, Laos	n.a.	42-74	n.a.	DeFoliart, 2002, Young-Aree et al., 2005

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Laccothrepes	Water scorpion	*Nepidae*	Indonesia	n.a.	42-74	n.a.	Meer, v.d. Mohr, 1965
Nepa sp.	Water scorpion	*Nepidae*	n.a.	n.a.	42-74	n.a.	DeFoliart, 2002
Ranatra	Water stick insect	*Nepidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong et al., 2000
Anisops	Backswimmer	*Notonectidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong et al., 2000
Anisops sp.	Backswimmer	*Notonectidae*	Laos	n.a.	42-74	n.a.	Young-Aree et al., 2005
Mantis	European mantid	*Mantidae*	Thailand	n.a.	n.a.	n.a.	Hanboonsong, et al., 2010
Notonecta	Backswimmer	*Notonectidae*	Thai., Mayn., Mala., Sabah	Adult	42-74	n.a.	DeFoliart, 2002
Nezara	Stink bug	*Pentatomidae*	Ind., Kal.	Adult	42-74	n.a.	Chung et al., 2002
Pygoplatys sp.	n.a.	*Tessaratomidae*	Thailand	n.a.	42-74	n.a.	Hanboonsong et al., 2000
Tessaratoma	Longan stink bug	*Tessaratomidae*	Thailand, Laos	Adult	42-74	n.a.	DeFoliart, 2002
Chremistica sp.	n.a.	*Cicadiae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Cosmopsaltria sp.	n.a.	*Cicadiae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Dundubia	n.a.	*Cicadiae*	Thailand, Laos	Adult	42-74	n.a.	DeFoliart, 2002
Dundubia	n.a.	*Cicadiae*	Malaysia, Sabah	Adult	42-74	n.a.	Chung et al., 2002
Dundubia sp.	n.a.	*Cicadiae*	Thailand, Malaysia	Adult	42-74	n.a.	Chung, 2010
Magicicada sp.	n.a.	*Cicadiae*	Thailand	Adult	42-74	n.a.	DeFoliart, 2002
Meimura	n.a.	*Cicadiae*	Laos	Adult	42-74	n.a.	Young-Aree et al., 2005
Meimura	n.a.	*Cicadiae*	Thailand	Adult	42-74	n.a.	Raksakantong et al., 2010

Table 5.: Edible insect in Southeast Asia

Latin name	**Common name**	**Family**	**Distribution**	**Life stages**	**Range - % protein**	**Consumption**	**References**
Orientopsaltria sp.	n.a.	*Cicadiae*	Malaysia, Sabah	Adult	42-74	n.a.	Chung, 2010
Orientopsaltria sp.	n.a.	*Cicadiae*	Thailand	Adult	42-74	n.a.	Hanboonsong et al., 2000
Platylomia sp.	n.a.	*Cicadiae*	Thailand	Adult	42-74	n.a.	Hanboonsong, 2010
Platylomia sp.	n.a.	*Cicadiae*	Indonesia, Malaysia	Adult	42-74	n.a.	Meer, v.d. Mohr, 1965
Platypleura	n.a.	*Cicadiae*	Myanmar	Adult	42-74	n.a.	DeFoliart, 2002
Pomponia	n.a.	*Cicadiae*	Malaysia, Indonesia	Adult	42-74	n.a.	DeFoliart, 2002, Chung, 2010
Pomponia sp.	n.a.	*Cicadiae*	Indonesia	Adult	42-74	n.a.	Meer, v.d. Mohr, 1965
Rihana	n.a.	*Cicadiae*	Thailand	n.a.	42-74	n.a.	DeFoliart, 2002
Flatiae sp.	Moth bug	*Flatidae*	Malaysia, Sabah	Adult	42-74	n.a.	Chung et al., 2010
Kerria	Indian lac insect	*Kerridae*	Thailand	n.a.	42-74	n.a.	DeFoliart, 2002
Laccifer	Indian lac insect	*Kerridae*	Thailnad	n.a.	42-74	n.a.	DeFoliart, 2002
Drosicha sp.	Giant mealybug	*Monophlebidae*	Laos	n.a.	42-74	n.a.	Nonaka et al., 2008
Apis	Indian honey bee	*Apidae*	Thailand, Philippines	Larvae, pupae, honey	13-77	Raw, fried	Adalla et al., 2010
Apis indicana F.	Indian honey bee	*Apidae*	Indonesia	Larvae, pupae, honey	13-77	Raw, fried	Meer, v.d. Mohr, 1965
Apis	Giant honey bee	*Apidae*	Thailand, Philippines	Larvae, pupae, honey	13-77	Raw, fried	Adalla et al., 2010

Table 5.: Edible insect in Southeast Asia

Latin name	**Common name**	**Family**	**Distribution**	**Life stages**	**Range - % protein**	**Consumption**	**References**
Apis	Giant honey bee	*Apidae*	Indonesia	Larvae, pupae, honey	13-77	Raw, fried	Meer, v.d. Mohr, 1965
Apis	Little honey bee	*Apidae*	Thailand	Larvae, pupae	13-77	n.a.	DeFoliart, 2002
Apis	Honey bee	*Apidae*	Thai., Mal., Viet.	Larvae, pupae	13-77	n.a.	DeFoliart, 2002
Bombus sp.	n.a.	*Apidae*	Indonesia	n.a.	13-77	n.a.	Meer, v.d. Mohr, 1965
Melipona	n.a.	*Apidae*	Indonesia	Larvae, pupae	13-77	n.a.	DeFoliart, 2002
Nannotrichona	Stingles bee	*Apidae*	Indonesia	Larvae, pupae	13-77	n.a.	DeFoliart, 2002
Nomi asp.	n.a.	*Apidae*	Thailand	Larvae, pupae, honey	13-77	n.a.	DeFoliart, 2002
Trigona	Stingles bee	*Apidae*	Philippines, Ind.	Larvae, pupae	13-77	n.a.	Adalla et al., 2010, DeFoliart, 2002
Trigona sp.	Stingles bee	*Apidae*	Indonesia	Larvae, pupae	13-77	n.a.	Meer, v.d. Mohr, 1965
Xylocopa	Carpenter bee	*Apidae*	Thai., Mal., Ind., Sabah	Adult, larvae, pupae	13-77	n.a.	DeFoliart, 2002; Chung et al., 2005; Lukiwati, 2010
Xylocopa sp.	Carpenter bee	*Apidae*	Mal., Ind., Kal.	Adult, larvae, pupae	13-77	n.a.	Chung et al., 2002
Camponotus	Giant forest ant	*Formicidae*	Malaysia	Adult	13-77	Fried	Chung, 2003
Camponotus sp.	Carpenter ant	*Formicidae*	Philippines, Ind.	Pupae	13-77	Fried	Adalla et al., 2010; Meer v.d. Mohr, 1965
Carebara	n.a.	*Formicidae*	Thailand	n.a.	13-77	n.a.	Hamboonsong et al., 2000
Crematogaster	n.a.	*Formicidae*	Indonesia	n.a.	13-77	n.a.	Meer, v.d. Mohr, 1965
Crematogaster sp.	Acrobat ant	*Formicidae*	Thai., Ind., Kal.	Larvae, pupae	13-77	n.a.	DeFoliart, 2002; Chung, 2003

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Latin name	**Common name**	**Family**	**Distribution**	**Life stages**	**Range - % protein**	**Consumption**	**References**
Oecophylla	Green tree ant, red ant	*Formicidae*	Thailand, Maynmar	All stages	13-77	n.a.	Chakravorty, 2013
Eumenes	Potter wasp	*Vespidae*	Thailand	Larvae, pupae	13-77	n.a.	DeFoliart, 2002
Polistes	Homet	*Vespidae*	Laos	n.a.	13-77	n.a.	Young-Aree et al., 2005
Provespa	Night wasp	*Vespidae*	Indonesia, Kal.	Brood	13-77	n.a.	Chung, 2003
Ropalidia sp.	n.a.	*Vespidae*	Malaysia, Sabah	Brood	13-77	n.a.	Chung et al., 2002
Vespa	n.a.	*Vespidae*	Malaysia	Larvae, pupae	13-77	n.a.	Chung et al., 2002
Vespa	n.a.	*Vespidae*	Thailand, Ind.	n.a.	13-77	n.a.	Hanboonsong et al., 2000; Meer v.d. Mohr, 1965
Vespa tropica	Greater banded homet	*Vespidae*	Thai., Ind., Mal.	Larvae, pupae, adult	13-77	n.a.	DeFoliart, 2002; Meer v.d. Mohr, 1965; Chung et al., 2002
Vespa v.	Asian predatory wasp	*Vespidae*	Maynmar	Larvae, pupae	13-77	n.a.	DeFoliart, 2002
Vespa sp.	n.a.	*Vespidae*	Thailand, Laos	Larvae	13-77	n.a.	DeFoliart, 2002; Young-Aree et al., 2005
Vespa syn.	n.a.	*Vespidae*	Indonesia	n.a.	13-77	n.a.	Meer v.d. Mohr, 1965
Kalotermes	Dry wood termite	*Kalotermitidae*	Thailand	Winged adult	n.a.	n.a.	DeFoliart, 2002
Odonotermes sp.	n.a.	*Termitidae*	Indonesia, Laos	n.a.	n.a.	n.a.	Meer v.d. Mohr, 1965
Termes	n.a.	*Termitidae*	Indonesia	Winged adult	n.a.	n.a.	DeFoliart, 2002

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Bombyx	Silk worm	*Bombycidae*	Thai., Mayanmar, Viet., Laos	Pupae	14-68	Raw, fried	DeFoliart, 2002
Zeuzera sp.	n.a.	*Cossidae*	Malaysia, Sabah	Larvae	14-68	Raw, fried	Chung et al., 2002
Brihaspa	n.a.	*Crambidae*	Vietnam	Larvae, pupae	14-68	Raw, fried	DeFoliart, 2002
Omphisa	Bamboo borer or worm	*Crambidae*	Thailand, Laos	Larvae	14-68	Raw, fried	Hanboonsong, 2010
Ancistroides	Chocolate demon	*Hesperiddae*	Malaysia	Larvae	14-68	Raw, fried	Chung, 2010
Erionata	Banana skipper	*Hesperiddae*	Malaysia, Thai., Ind.	Larvae, pupae	14-68	Raw, fried	Chung, 2010; Hanboonsong, 2010
Hybleae	Teak defoliator	*Hesperiddae*	Indonesia	Larvae, pupae	14-68	Raw, fried	Lukiwati, 2010
Liphyra	n.a.	*Lycaenidae*	Indonesia	Larvae	14-68	Raw, fried	Eastwood, 2010
Catopsilia sp.	n.a.	*Pieridae*	Indonesia	Larvae	14-68	Raw, fried	Meer, v.d. Mohr, 1965
Eurema	n.a.	*Pieridae*	Indonesia	Larvae	14-68	Raw, fried	Meer, v.d. Mohr, 1965
Cricula	n.a.	*Saturniidae*	Indonesia	Pupae	14-68	Raw, fried	Roepke, 1951
Acherontia	n.a.	*Sphingidae*	Indonesia	n.a.	14-68	n.a.	Meer, v.d. Mohr, 1965
Agrius	n.a.	*Sphingidae*	Indonesia	Larvae	14-68	Raw, fried	Meer, v.d. Mohr, 1965
Epophalmia	n.a.	*Corduliidae*	Thailand	Nymph	46-65	n.a.	DeFoliart, 2002
Cratilla	n.a.	*Libellulidae*	Indonesia	Adult	46-65	n.a.	Cesard, 2006
Crocothemis	n.a.	*Libellulidae*	Indonesia	Adult, nymph	46-65	Fried	Cesard, 2006

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Crocothemis sp.	River skimmer	*Libellulidae*	Indonesia, Laos	Adult, nymph	46-65	Fried	DeFoliar, 2002; Young-Aree et al, 2005
Libellula	n.a.	*Libellulidae*	Thailand	Nymph	46-65	Fried	DeFoliart, 2002
Libelludiae gen.	Skimmer	*Libellulidae*	Thailand	Nymph	46-65	Fried	DeFoliart, 2002
Neurothemis	n.a.	*Libellulidae*	Indonesia	n.a.	46-65	n.a.	Cesard, 2006
Neurothemis sp.	n.a.	*Libellulidae*	Indonesia	Adult, nymph	46-65	Fried	DeFoliart, 2002
Orthetrum	n.a.	*Libellulidae*	Indonesia	Adult	46-65	n.a.	Cesard, 2006
Orthetrum sp.	n.a.	*Libellulidae*	Malaysia, Sabah	n.a.	46-65	n.a.	Chung et al., 2002
Pantala	n.a.	*Libellulidae*	Indonesia	Adult	46-65	n.a.	Lukowati, 2010
Potamarcha	n.a.	*Libellulidae*	Indonesia	Adult	46-65	n.a.	Cesard, 2006
Rhyothemis sp.	n.a.	*Libellulidae*	Thailand	Nymph	46-65	Fried	DeFoliart, 2002
Tramera	n.a.	*Libellulidae*	Indonesia	n.a.	46-65	n.a.	Meer, v.d. Mohr, 1965
Trithemis	n.a.	*Libellulidae*	Indonesia	n.a.	46-65	n.a.	Cesard, 2006
Macroma sp.	River skimmer	*Macromiidae*	Thailand	Nymph	46-65	Fried	DeFoliart, 2002
Acrida	n.a.	*Acrididae*	Thailand, Laos	n.a.	23-65	n.a.	Hanboonsong et al., 2000; Young-Aree et al., 2005
Acrida sp.	n.a.	*Acrididae*	Thai., Mal., Sabah	n.a.	23-65	n.a.	Hanboonsong, 2010; Chung et al., 2002
Ailopus	n.a.	*Acrididae*	Thailand	Adult	23-65	n.a.	DeFoliart, 2002
Aiolopus sp.	n.a.	*Acrididae*	Malaysia, Sabah	n.a.	23-65	n.a.	Chung et al., 2002

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Aeschna sp.	n.a.	*Aeschnidae*	Thailand	Nymph	46-65	Fried	Hanboonsong et al., 2000
Anax	Hairy emperor	*Aeschnidae*	Thai., Ind., Laos	Adult	46-65	n.a.	Cesard, 2006; Meer, v.d. Mohr, 1965
Anax sp.	n.a.	*Aeschnidae*	Indonesia	Adult, nymph	46-65	n.a.	DeFoliart, 2002
Ceriagrion sp.	Damselfly	*Coenagrionidae*	Thailnad, Laos	n.a.	46-65	n.a.	Hanboonsong, 2010; Young-Aree et al., 2005
Catantops	n.a.	*Acrididae*	Thailand	n.a.	23-65	n.a.	DeFoliart, 2002
Chondacris	n.a.	*Acrididae*	Thailand	Adult	23-65	n.a.	Hanboonsong et al., 2000
Chortippus sp.	n.a.	*Acrididae*	Thailand	n.a.	23-65	n.a.	Hanboonsong, 2010
Cyrtacanthacris	Black spotted	*Acrididae*	Thailand, Ind.	Adult	23-65	n.a.	DeFoliart, 2002
Ducetia	n.a.	*Acrididae*	Thailand, Laos	n.a.	23-65	n.a.	Hanboonsong, 2010
Gastrimargus	n.a.	*Acrididae*	Indonesia	n.a.	23-65	n.a.	Meer, v.d. Mohr, 1965
Locusta	Migratory locus	*Acrididae*	Thailand	Adult	23-65	n.a.	Hanboonsong et al., 2000
Mecostethus sp.	n.a.	*Acrididae*	Thailand	n.a.	23-65	n.a.	Hanboonsong, 2010
Oxya	n.a.	*Acrididae*	Ind., Thai., Mal., Viet.	Adult	23-65	n.a.	Meer, v.d. Mohr, 1965; DeFoliart, 2002
Parapleuris sp.	n.a.	*Acrididae*	Thailand	n.a.	23-65	n.a.	Hanboonsong, 2010
Patanga	Bombay locus	*Acrididae*	Thai., Phil., Ind.	Adult	23-65	n.a.	Hanboonsong, 2010; DeFoliart, 2002; Meer, v.d. Mohr, 1965

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Phlaeoba	n.a.	*Acrididae*	Indonesia	Adult	23-65	n.a.	Meer, v.d. Mohr, 1965
Shirakiacris	n.a.	*Acrididae*	Thailand	n.a.	23-65	n.a.	Hanboonsong, 2010
Stenocatantops	n.a.	*Acrididae*	Indonesia	n.a.	23-65	n.a.	Meer, v.d. Mohr, 1965
Trilophidia	n.a.	*Acrididae*	Thailand	n.a.	23-65	n.a.	Hanboonsong et al., 2000
Valanga	n.a.	*Acrididae*	Ind., Mal., Sabah	n.a.	23-65	n.a.	Lukiwati, 2010
Ratanga (misspelling)	n.a.	*Catantopidae*	Thailand	n.a.	23-65	n.a.	Hanboonsong, 2010
Acheta	n.a.	*Gryllidae*	Thailand, Laos	Adult	23-65	Fried	Hanboonsong et al., 2015
Brachytrupes sp.	n.a.	*Gryllidae*	Thailand, Laos	Adult	23-65	Fried	Hanboonsong, 2010; Hanboonsong and Durst, 2014
Gryllus	Two spotted cricket	*Gryllidae*	Thailand, Laos	Adult	23-65	Fried	Hanboonsong, 2010; Young-Aree et al., 2005
Gryllu sp.	n.a.	*Gryllidae*	Thailand	Adult	23-65	Fried	Hanboonsong, 2010
Gryllus sp.	n.a.	*Gryllidae*	Thailand	Adult	23-65	Fried	DeFoliart, 2002
Gymnogryllus	n.a.	*Gryllidae*	Indonesia	Adult	23-65	Fried	Meer, v.d. Mohr, 1965
Gymnogryllus	n.a.	*Gryllidae*	Thailand	Adult	23-65	Fried	Hanboonsong, 2010
Gymnogryllus sp.	n.a.	*Gryllidae*	Indonesia	Adult	23-65	Fried	Meer, v.d. Mohr, 1965
Homoexipha sp.	n.a.	*Gryllidae*	Thailand	Adult	23-65	Fried	Hanboonsong, 2010

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Modicogryllus	n.a.	*Gryllidae*	Thailand, Laos	Adult	23-65	Fried	Hanboonsong, 2010; Young-Aree et al., 2005
Nisitrus	n.a.	*Gryllidae*	Indonesia	Adult	23-65	Fried	Meer, v.d. Mohr, 1965
Pteronemobius sp.	n.a.	*Gryllidae*	Thailand	Adult	23-65	Fried	Hanboonsong, 2010
Tarbinskiellus	n.a.	*Gryllidae*	Thai., Ind., Mayn., Viet.	Adult	23-65	Fried	Lukiwati, 2010
Teleogryllus	n.a.	*Gryllidae*	Thailand, Ind.	Adult	23-65	Fried	Hanboonsong, 2010; Meer, v.d. Mohr, 1965; Young-Aree et al., 2005
Teleogryllus sp.	n.a.	*Gryllidae*	Thailand	Adult	23-65	Fried	Hanboonsong, 2010
Teleogryllus sp.	n.a.	*Gryllidae*	Thailand	Adult	23-65	Fried	Hanboonsong, 2010
Velarifictorus sp.	n.a.	*Gryllidae*	Thailand	Adult	23-65	Fried	Hanboonsong, 2010
Gryllotalpa	African mole cricket	*Gryllotalpidae*	Thai., Phil., Viet., Ind., Laos	Adult, nymph	23-65	Fried	DeFoliart, 2002
Gryllotalpa	n.a.	*Gryllotalpidae*	Malaysia, Sabah	n.a.	23-65	n.a.	Hanboonsong et al., 2000
Gryllotalpa sp.	Mole cricket	*Gryllotalpidae*	Indonesia, Phil.	Adult	23-65	Fried	Hanboonsong, 2010
Gryllotalpa sp.	n.a.	*Gryllotalpidae*	Thailand	Adult	23-65	Fried	DeFoliart, 2002
Acratomorpha	Spotted grasshopper	*Gryllotalpidae*	Malaysia, Sabah	Adult	23-65	Fried	Hanboonsong, 2010
Acratomorpha sp.	n.a.	*Gryllotalpidae*	Thailand	Adult	23-65	Fried	Meer, v.d. Mohr, 1965

Table 5.: Edible insect in Southeast Asia

Latin name	Common name	Family	Distribution	Life stages	Range - % protein	Consumption	References
Euparatettix sp.	n.a.	*Tetrigidae*	Thailand	Adult	23-65	Fried	Hanboonsong et al., 2000
Arachnacris	n.a.	*Tettigoniidae*	Malaysia, Sabah	Adult	23-65	Fried	Chung et al., 2002
Conocephalus	n.a.	*Tettigoniidae*	Thailand	Adult	23-65	Fried	Hanboonsong et al., 2000
Conocephalus sp.	n.a.	*Tettigoniidae*	Thailand	Adult	23-65	Fried	Hanboonsong, 2010
Euconocephalus	n.a.	*Tettigoniidae*	Thailand	Adult	23-65	Fried	Hanboonsong et al., 2000
Euconocephalus sp.	n.a.	*Tettigoniidae*	Vietnam, Laos	Adult	23-65	Fried	DeFoliart, 2002; Young-Aree et al., 2005
Hexacentrus	n.a.	*Tettigoniidae*	Malaysia, Sabah	Adult	23-65	Fried	Chung et al., 2002
Mecapoda	n.a.	*Tettigoniidae*	Thai., Ind., Laos	Adult	23-65	Fried	Hanboonsong and Durst, 2014; Meer, v.d. Mohr, 1965
Onomarchus sp.	n.a.	*Tettigoniidae*	Thailand, Malaysia	Adult	23-65	n.a.	Hanboonsong, 2010
Pseudophyllus	n.a.	*Tettigoniidae*	Thailand, Laos	Adult, larvae	23-65	n.a.	Hanboonsong, 2010; Young-Aree et al., 2005
Scudderia sp.	n.a.	*Tettigoniidae*	Thailand	Adult	23-65	n.a.	DeFoliart, 2002
Haaniella	Stick insect	*Heteropterygidae*	Malaysia, Sabah	Egg	n.a.	n.a.	Chung et al., 2002; DeFoliart, 2002
Eurycnema	n.a.	*Phasmatidae*	Malaysia	Excreta	n.a.	n.a.	DeFoliart, 2002
Pediculus	n.a.	*Pediculidae*	Indonesia	Adult	n.a.	n.a.	Roepke, 1951

4.3.2 Farming and farms in SE Asia

The most commonly bred insects in Southeast Asia are the native cricket (*Gryllus bimsculatus*), which is better from economic standpoint and the house cricket *(Acheta domescticus*), which has a better taste and quality. These species of crickets is possible to find most often in farms in Thailand (Hanboonsong, 2012).

All cricket rear methods are quite similar in many Southeast Asian countries. These are mainly Thailand, Vietnam and Lao People´s Democratic Republic. Crickets in these countries behave as the least costly insects. They live in the gardens under the shelters. For breeding concrete ring approximately 0.5 m in height and 0.8 m in diameter are used (e.g. Thailand, Lao People´s Democratic Republic). In addition, some plastic dishes are used somewhere (e.g. Vietnam). On the bottom is always the rice waste, because rice is the most common food in these countries. Food for crickets is simple. They are fed with vegetables, rice, feed for livestock, but also with grass and organic waste. The crickets consume water mostly from food (in case it contains enough water). If the crickets receive dry feed as food, it is advisable to place a plastic plate of water in the enclosure where stones are placed to prevent drowning of the cricket. Alternatively, using plastic bottles attached to the wall of the enclosure. If there is not plastic cork or other slippery material, an adhesive tape must be glued to the wall so that the cricket can not crawl on the walls and run out. Often in pots with crickets are cardboard egg or hollow logs. It is used to create a larger amount of space. In the enclosure are the sand and rice boxes, where the females lay eggs. These boxes will later be moved and the new generation will be established. The top of the box is often a mosquito net, which prevents other animals from entering inside (e.g. geckos). The rearing areas are surrounded by a "moat" with water and small fish, that prevents ants from entering (Young-Aree & Viwatpich, 2005; van Itterbeeck, personal communication, 2008).

In each area, insects that are typical of the area should be kept. Reared insects should be the least demanding of breeding and should be quickly and easily reproduced. And feed and space for the insects should be as simple as possible (van Huis et al., 2013).

Farms in SE Asia

Entobel

Country: Vietnam

Country expertise: Vietnam

Entobel has developed a bioconversion model based on what nature has done for millions of years. By converting low-value biomass into high grade products thanks to insects (species: *Hermetia illucens* – Black soldier fly). Entobel technology represents the missing link in our global food chain. Entobel made many products from Black soldier fly (H-Meal, H-Oil, H-Ferti). While fully automated and high codex technologies may have their merits in temperate developed countries, tropical developing regions such as Vietnam have their own constraints and opportunities to leverage. Insect production models must be adapted accordingly. Entobel has acquired relevant and sound production principles from its German partner katz Biotech-Hermetia GmbH, pioneer in Black soldier fly rearing and processing in Europe. The whole process from egg production to final product processing has been adapted to the tropical and developing countries. Entobel technology is cost efficient, easily transferable and has low capital intensity. Entobel specializes in the production of the *Hermetia ilucesns* in developing countries where lower production costs can be achieved as well lower carbon footprint.

Entofood

Country: Malaysia

Country expertise: Malaysia

Since 2012, Entofood operates a pilot farm of Black soldier fly (*Hemetia illuscens*) in Malaysia and launched trials on different species to confirm the potential of insect-based products as an alternative and sustainable source of protein (FAO, 2013).

Entofood is developing industry, oriented model of insect-mass production. During the past years Entofood gathered a large factual database on insect zoology, breeding, nutritional profile of insect-based product and their application in aquaculture and livestock industry. This gives to the company a unique asset to offer services, forecasts and industrial development with a very high degree of reliability. In 2013, the company was awarded with the Bionexus status from the Malaysia Biotechnology Corporation for its proven bio-conversion technology to process organic waste into animal proteins for animal feed and organic fertilizer for plant nutrition. Entofood has conceived, studied and validated automated production lines (processing of organic side-stream, grow-out-facility, harvesting and processing of finished products) to enable rollout of large-scale operations. Technical choice has been made, taking in to account market needs of volume, production cost and quality. Entofood is an associated member of the International Platform of Insects for Food and Feed (IPIFF) bringing together 28 members operating in the insect value chain, all over the world. The company is also involved in the insect professional group AFFIA (Entofood, 2012).

Some company of edible insect had to end, because farming the edible insect is still in the beginning. And the companies do not have a necessary information about farming insect. As an example, is the company called Co-Prot.

Co-Prot

Country: Cambodia

Country expertise: Cambodia

In 2011 this company produced and marked Black soldier fly larva for animal feed applications. They have decided to close the venture because they concluded that mass insect production for animal feed is not a sound investment. Because lot of companies has not some manual for farming edible insect. They not know how feed they need, how many place, they need and many information about farming insects. Their farm was located in Southeast Asia, they expected commercial quantities at the end of 2015. The company must be ended on August 2015 (FAO, 2016).

4.3.3 Projects of edible insect in SE Asia

In August 2016, a dozen regional insect business owners, met in Bangkok to create AFFIA the Asian Food as Feed Insects Association. It sets out to represent Southeast Asian insect companies but is also open to business in other Asia-Pacific countries through external membership. In coming years, the association plants to spread the idea that insects are a viable solution to food shortages, both directly human food and indirectly as animal feed among founders are brands including Smile Bull Marketing and Bugsolutely, each of Thailand, as well as Malaysia´s Entofood., Vietnam´s Entobel and Eawag of Indonesia (Reverberi, 2017).

AFFIA plants to communicate the advantages of edible insects and try to create solid ground for the development of the industry for example. Starting a conversation with public agencies. The Southeast Asian tradition of farming and eating insects goes back in time, but is not codified on legislation, not even in best practices. There is still no manual for farming crickets, nor an HS (Harmonized system) code for insects within the World Custom Organisation. The FAO´s Codex Alimetarius does not mention bugs as food, although a few years ago Laos proposed introducing new standards for them. Futher, AFFIA affirms creation of knowledge base for its members. This is to fill an existing gap in terms of information, not least because there is little publicly available information on how to farm, process and export insects. The membership fees have been set at symbolic 50 USD and will be used to support small processors and farmers, which form the majority of the sector (Reverberi, 2017).

Since 2003, the FAO has been conducting many projects around the world that concern entomophagy. It brings many experts and people involved in insects as food. It passes information and awareness of insects as a food and very suitable alternative. It points out that insects contain many nutrients for humans. The organization also advise how insect behave and how to prepare them. It also supports the media and the social network so that as many people as possible can learn about entomophagia around the world (van Huis et. al., 2013).

Two of the most important milestones in Southeast Asia are listed below.

Workshop in Chiang Mai, Thailand, 2008

FAO Regional Organization in February 2008 created a workshop called ”Forest Insects as Food: Humans Bite Back” for Asia and Pacific. The meeting was held in Thailand in Chiang Mai and many world entomophagic experts met. There were specialists focusing mainly on insect breeding, its processing, management and collection of insects from the wild. There was a project on how to implement insect breeding by local farmers. Also pointed to the contribution of rural insect consumption and insects as a suitable alternative to animal protein and the food of good health (van Huis et al., 2013).

Laos programme, 2010 – 2013

National Nutrition Strategy and National Plan of Action for Nutrition were adopted in Lao People´s Democratic Republic in December 2009 to promote improved nutrition and health of people, increase nutrients in food and improve food availability and self-sudiciency of people to produce their own food at home. A year followed by FAO project, which lasted until 2013 and was called ”Sustainable insect farming and harvesting for better nutrition, improved food security, and household income generation”. The main objective of this project is to focus on insects as a suitable food, to try to collect insects can become sustainable food. The insect breeding itself, its preparation so as to use as much of all the nutrients that insects contain (van Huis et al., 2013).

5. Conclusion

Alternative source of animal protein in Southeast Asia represented by edible insect was studied in this thesis. This study analysed 62 insect orders and described processing methods of five insect species more detailed, namely red palm weevil, grasshoppers, wasp crickets and giant water bug. According to latest studies (van Huis, 2013 and Hanboonsong, 2012) in Southeast Asia lives a big amount of edible insects, but there is no definitive number because some insect species are consumed in one or two stages of their life cycles. Therefore, it is still necessary research to prove the final number.

The result of this study showed that insects have very good nutritional values, which are essential for human diet. According to (van Huis, 2013 and Hanboonsong, 2012), insects contain a high fat, protein, vitamins and minerals, in some cases higher rate than chicken of fishes, which are the most commonly consumed in Southeast Asia. This work investigated species with the highest protein content as follows: order Hymenoptera (range 13 – 77 percent of dry matter) and order Hemiptera (range 42 – 74 percent of dry matter).

A very high potential has insect farms built in Southeast Asia in recent years. Insects are mostly harvested in nature. However, this is not possible for sustainable development, despite the great reproduction and big amount of insects it can´t be considered as inexhaustible source in nature.

Insects play a very important role in preserving the environment and human life. For these reasons in the past few years there have been launched some projects that are focussed on using insects as food and trying to spread the awareness of edible insects all over the world. Entomophagy is promising alternative for conventional meat production and for human consumption or as a feed for livestock.

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