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Insects as a Delicacy and a Nutritious Food in Thailand

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INTRODUCTION

The consumption of edible insects has a long history for many cultures. Edible insects have played an important role as a part of human nutrition in many regions around the world such as Africa, Asia and Latin America [1]. More than one thousand insect species, edible at some stage of their life cycle, are reported worldwide as traditional foods for humans, representing important parts of the nutritional intake and economic resources of many societies [2]. For example, there are 524 in Africa, 349 in Asia, 679 in the Americas, 41 in Europe and 152 species in Australia [3]. Mexico has the most registered species, followed by Thailand, Congo and Zaire, India, Australia, China and Zambia [4].

Among edible insects with nutritional value, 194 species are reported in Thailand. Of these, beetles are the major group (61 species), followed by Lepidopterans (47 species), crickets and grasshoppers (22 species), Hymenopterans (16 species), Hemiperans (11 species), Homopterans (11 species) and dragon flies (4 species) [5].

As people in rural areas suffer from under nutrition, especially protein-energy malnutrition (PEM) in Africa, Latin America and Asia, alternative nutritional food sources are needed. Rural communities of Thailand, especially those from northern and northeastern Thailand, have a long cultural history of eating insects. In these regions, where over half of the Thai population reside, socio-cultural and economic limitations often impede the use of more common protein sources such as pork, beef, poultry, milk and eggs [6]. While there is a western reluctance to eat insects, probably more than half of the world's people regularly eat them and they contribute significant amounts to their total animal protein intake [7]. Edible insects are readily available and commonly consumed by rural people, serving as an important protein source [8]. In Thailand, there are large numbers of many species of edible insects used as food. The characteristics of Thai edible insects including their common names, Thai names and scientific names are shown in Table 1.

Over recent decades, edible insects have been used in value-added products such as canned foods or even snacks on a commercial scale. This chapter aims to provide information about the nutritional quality of selected edible insects consumed in the Thai community. We also report on the market distribution of insect-based food products in Thailand and some value-added foods from insects.

SOURCES AND AVAILABILITY

In Thailand, insect eaters can be found in all regions of the country. In the past, indigenous insect eaters were known to reside mostly in the north and northeast [9]. In these regions, insects can be collected from paddy fields, upland and forested areas, natural ponds and streams; some kinds of Thai edible insects are available all year round [10]. Sangpradub (1982) reported that insects account for 44 percent of edible invertebrates in the northeast region [11].

Table 1. Characteristics and seasonal availability of edible insects in local markets in Thailand.

Scientific name	Common English name/ Thai name	Season of sale	Price per kilogram* (US dollar)
Meimuna opalifera Walker	Cicada / Juk-jan	Mainly the rainy season (May-June)	~9.5
Copris nevinsoni Waterhouse	Dung beetle / Kud chi	Mainly the rainy season (May-October)	~2.5-3.2
Lethocerus indicus Lep.-serv	Giant water bug / Maeng da na	Most or all of the year	~3.8-4.8
Acheta confirmata Walker	Ground cricket / Ching reed, Chi reed	A short period at the end of the rainy season (September-October)	~3.8
Holotrichia sp.	June beetle / Malaeng kinoon	Mainly the rainy season (May-October)	~5.1
Tessaratoma papillosa	Longan stink bug / Maeng krang	Most or all of the year	~3.2
Gryllotalpa africana Beauvois	Mole cricket / Krachorn	Season rice harvest (November-January)	~4.8
Brachytrupes portentosus Lichtenstein	Short tailed cricket / Ching klong	Most or all of the year	~4.8
Chondracris roseapbrunner Uvarov	Spur-throated grasshopper/ Tukkatan, Tucka tan	Mainly the rainy season (May-October)	~7.6-8.0
Termes sp.	Termite / Malaeng mao	Mainly the rainy season (May-October)	~2.5
Cybister limbatus Fabricius	True water beetle/ Malaeng tub tow	Mainly the rainy season (May-October)	~4.5
Hydrous cavistanum Bedel	Water scavenger beetle/ Malaeng nian	Mainly the rainy season (May-October)	~3.2
Oecophylla smaragdina Fabricius	Weaver ant / Mod daeng	Mainly the dry season (February-April)	~9.5-12.7
Bombyx mori Linnaeus	Silk worm pupae / Duck dae tua mai	Most or all of the year	~3.8
Omphisa fuscidentalis	Bamboo caterpillar / Rot-duan, Duang mai pai	Season rice harvest (October-February)	~9.5
Oecophylla smaragdina Fabricius	Queen caste / Mae peng	Mainly the dry season (February-April)	~3.5

*from interviews with the sellers.

Although a number of insect species is available throughout the year, some can only be obtained for a short season, dependent either on weather or other natural circumstances. Insects are often collected and consumed by local people [12]. A list of seasons of availability of Thai edible insects in local Thai markets is presented in Table 1. In the past decade, a large number of insects have become available in Thailand for domestic consumption. However, available insects have decreased in both quantity and in the number of species [13], due to increased demand and decreased insect habitats. Nowadays, the insects sold on local markets in Thailand are mostly imported from Cambodia where there are still ample natural habitats for insects. Nevertheless, Thailand is considered to be a large commercial market with insect consumption now extended to urban areas and not merely limited to rural areas as previously.

COOKING THAI EDIBLE INSECTS

A wide range of insects is consumed at various stages of their life cycles. For example, silkworms are eaten at both the larval and pupae stages. Aquatic insects like dragonflies, predaceous diving beetles and water scavenger beetles are eaten at the nymphal stage. Ants can be consumed at the egg, pupae and adult stages [13]. They can be cooked in various ways and served as side dishes eaten with sticky rice. Local Thai people have used their traditional knowledge for a long time to cook each insect species in a different way; for example deep fried, fried with spices or roasted. The characteristics of local style cooking are shown in Table 2. Cooked edible insects are not only sold at roadside food stalls in various cities of Thailand, but nowadays can also be found prepared commercially in cans. Canned insects are easy to prepare and can be stored for several months or years [13].

Table 2. The characteristics of local style cooking.

Insect	Local style cooking
Cicada	Roasted, fried, toasted, Dipping (mixed with chili paste), Koy (chopped cicada cooked in Northeastern Style)
Dung beetle	Curry, chili paste, fried
Giant water bug	Chili paste, roasted
Ground cricket	Steamed, curried, fried, roasted
June beetle	Roasted, fried, steamed, lightly curried with vegetables, dipping
Longan stink bug	Roasted, curried, chili paste
Mole cricket	Fried, Curried
Short tailed crickeT	Roasted, fried, toasted
Spur-throated grasshopper	Steamed, fried, roasted
Termite	Roasted (with salt), fried
True water beetle	Roasted, lightly curried, fried
Water scavenger beetle	Lightly curried, fried
Weaver ant	Salad (yum khai mod daeng), lightly curried with vegetables
Silk worm pupae	Fried, steamed, with chili paste, lightly curried with vegetables
Bamboo caterpillar	Fried, with chili paste, lightly curried with vegetables
Queen caste	Steamed queen caste with curry paste, Thai spicy salad

NUTRITIONAL QUALITY

1. Proximate composition

Based on a study of the nutritive value of insect species commonly eaten in Thailand, Raksakantong et al. (2010) concluded that insects represent the cheapest source of animal protein in Thailand and that their consumption should be encouraged because many people cannot afford fish or other meat [8]. Their results help demonstrate the importance of edible insects for the intake of high quality protein in the population of this region. However, there is need for caution due to the caloric deficiency in the diet of these people as protein cannot be fully utilized if there is not enough energy in their meals [14]. Insects have been shown to contain a large quantity of protein ranged from 38% in queen castes to 54% in dung beetles. These values are higher than those reported for edible insects in southwestern Nigeria (from 6% for *Brachytrypes* spp. to 30% for *Analeptes trifasciata*) [15]. Values are even higher for dung beetles at the larval and adult stages (50% to 53% for *Zonocerus variegatus*) [16]. However, the protein value for dung beetles was lower than the values reported in the wasp *Polybia sp.* (82%) [15]. The high protein content is an indication that the insects can be of value in human and animal rations, thus replacing more costly sources of animal protein that are usually absent in the diet of rural dwellers in developing countries [15]. Besides the high amounts of protein that insects can provide, several investigations have demonstrated their high quality and high digestibility in a great variety of species [14]. The quality of the protein, and thus its nutritional value, is determined by the amino acid composition and the digestibility of the protein [17]. Table 3 shows the essential amino acids from Thai edible insects, as well as the nutritional requirements for adults and preschoolers. Since children are in the growth phase, their need for amino acids is greater compared to adults. Most insects provide a sufficient range of amino acids to fulfill the nutritional requirements of children. The essential amino acid content score of edible Thai insects ranges from 34 to 100% [18]. The limiting essential amino acid found in Thai edible insects is either threonine or lysine, while that of other insects from the State of Oaxaca, Mexico, is either tryptophan or lysine [14]. The amino acids of different protein sources may have a complementary function [19]. Therefore, Thai edible insects can effectively supply protein by complementing other animal protein sources.

Table 3. Essential amino acid contents of Thai edible insects (mg/100 g dry weight) and daily requirements for humans (mg/kg body weight per day)

Insects	Essential amino acid								Amino acid score	Limiting amino acid
	Ile	Leu	Lys	Met + Cys	Phe + Tyr	Thr	Trp	Val		
Ground cricket	29.8	60.9	46.0	30.9	62.4	29.0	24.4	34.4	68.7	Threonine
Silk worm pupae	46.1	70.6	77.2	36.3	122.0	45.3	19.0	52.2	100	-
Spur-throated grasshopper	32.7	59.5	35.7	20.9	60.0	22.3	17.3	35.6	55.8	Threonine
Bamboo caterpillar	33.9	60.0	56.0	41.8	100.8	34.9	41.1	38.8	77.5	Threonine
June beetle	32.1	51.8	18.8	44.6	49.3	26.9	27.1	29.3	34.2	Lysine
WHO/FAO										
Preschooler	28	66	58	25	63	34	11	35		
Adult	13	19	16	17	19	9	5	13		

Adapted from [18]. Ile : Isoleucine, Leu: Leucine, Lys : Lysine, Met : Methionine, Cys : Cysteine, Phe : Phenylalanine, Tyr : Tyrosine, Thr : Threonine, Trp : Tryptophan and Val : Valine.

The carbohydrate content of Thai edible insects are relatively low, ranging from 7% in Longan stink bugs to 16% in cicadas. Similar results were observed in other insects from Nigeria, whose carbohydrate contents ranged from 7 to 20% [20]. Recent research has revealed that insects have considerable amounts of polysaccharides that can enhance the immunity function of the human body [21]. Low carbohydrate–high protein (LC-HP) diets, introduced originally for weight-loss regimens, also have significantly beneficial effects in reducing the risk of cardiovascular disease. Furthermore, such diets lower the intake of calories, resulting in expected weight loss [22].

The lipid content of some Thai edible insects varies widely. Raksakantong et al. (2010) found that the percentage of lipid ranged from 5 % in June beetles to 37 % in queen castes [8]. Similar results were observed in other Thai edible insects, with lipid contents ranging from 3 to 20%. This finding is in agreement with previous studies in which lipid contents varied significantly between species. The giant water bug, which lives in freshwater, had the highest lipid content (20%), followed by the mole cricket (13%), which lives on grass, while water scavenger beetles had the lowest (3%) [23]. These results suggest that habitat, diet and insect species may contribute to lipid content [24]. Lipids are essential in diets as they increase the palatability of foods by absorbing and retaining their flavours [25]. Lipids are also vital in the structural and biological functioning of cells, helping in the transport of nutritionally essential fat-soluble vitamins [26].

The fibre and ash contents of Thai edible insects share similar trends. The amount of fibre seems to be associated with that of ash in the group of insects studied by Raksakantong et al. (2010). The higher the fibre content, the greater the amount of ash. Insects that have a hard body, which has high chitin content, had high fibre and ash contents [8]. A few studies have reported that ash and fibre contents varied greatly among Thai edible insects depending on their sources and on the insect species. For instance, Raksakantong et al. (2010) found that the fibre content of Thai edible insects from Mahasarakham Province ranged from 6% in termites to 19% in June beetles [8]. Similar results were observed in other Thai edible insects from Baan Koksri, Khonkaen Province [27]. The ash contents of Thai edible insects from the first research group ranged from 2% in queen castes to 12% in June beetles [8], while the latter group found higher levels [27]. In comparison to the data obtained from other countries, the contents of fibre and ash varied among sources and species, such as *Trinervitermes germinatus* (5%) and *Analeptes trifasciata* (4.2%) [28] *Polyrhachis vicina* Roger (edible Chinese black ant) (13.2%), *Chrysichthys* species (17.9%) and the aquatic bugs that formed the 'ahuahutle' (eggs) (*Corisella spp., Krizousacorixa sp., Krizousacorixa femorata, Corisella mercenaria, Notonecta unifasciata*) (19%), 'axayacatl' (adults) (18%), and the grasshopper mixture of *Sphenarium histrio, Sphenarium purpurascens, Plectottetia nobilis, Arphia falax,* and *Melanoplus sp.* (16.5%) [29; 14; 26; 30].

These data establish Thai edible insects as good sources of nutrients, providing a good supplement to the Thai diet. Besides, they have a long history of safe consumption.

2. Fatty Acid Composition and Concentration

Polyunsaturated fatty acid (PUFA) is the predominant fatty acid found in Thai terricolous edible insects, followed by saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) [8]. The fatty acid composition of Thai edible insects is shown in Table 4. The concentration of total PUFAs in Thai terricolous insects ranged from 213 mg/100g in cicada to 1515 mg/100g in dung beetles, while Thai aquicolous insects ranged from 726 mg/100g in water scavenger beetles to 2544 mg/100g in giant water bugs [8; 23]. However, other studies [23; 27] reported that MUFA was the major fatty acid in other Thai edible insects. This indicates that habitat, diet and insect species may contribute to their fatty acid contents [23]. The total concentration of PUFAs can be compared to red meat and some fish such as sand whiting and black bream [31; 32] and much more than that found in fresh vegetables [33]. Consumption of PUFAs is of increasing interest as evidenced in the literature, especially n-3 PUFA, which have beneficial effects on reducing the risk of diabetes by reduction of glucose intolerance [34], prevention of insulin resistance, reducing blood pressure, lowering LDL cholesterol and helping to prevent several diseases such as thrombosis, hypertension, inflammatory disease, arrhythmia and coronary heart disease. PUFAs are essential to ongoing good health [35;36]. Many Thai edible insects have been found to contain three omega-3 (n-3) PUFAs, namely alpha-linolenic acid (ALA, 18:3n-3), eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3), plus two omega-6 (n-6) PUFAs, namely dihomo-linolenic acid (DGLA, 20:3n-6) and arachidonic acid (ARA, 20:4n-6). DGLA was found in all insects studied [8].

The highest concentration of total fatty acids was in the giant water bug (473 mg/100g), while EPA and DHA contents were found in all of Thai aquicolous insects, ranging from 149 to 569 mg/100g and 57 to 264 mg/100g, respectively. This composition is much higher than that found in sand whiting, mackerel, blue fish, sea bream, sea bass and marbled spinefoot [37]. For Thai terricolous insects, EPA was only found in dung beetles (301 mg/100g), while DHA was only found in June beetles (26 mg/100g) and Weaver ants (12 mg/100g). DGLA, arachidonic acid (ARA) and EPA are the precursors for prostaglandins which are products of essential fatty acid metabolism; they are often referred to as eicosanoids. EPA has also been reported to be useful in brain disorders and cancer treatment [38]. DHA is a major component of brain, eye retina and heart muscle, DHA has been considered important for brain and eye development, and also makes a valuable contribution to cardiovascular health. Consumption of DHA at 0.5–0.7 g/day can lower the incidence of heart disease [37; 39; 40].

Table 4. Fatty acid composition of Thai edible insects (mg/100 g)

Fatty acid	Terricolous insect*								Aquicolous insect**		
	June beetle	Queen caste	Weaver ant	Termite	Cicada	Longan stink bug	Dung beetle	Short tailed cricket	Giant water bug	True water beetle	Water scavenger beetle
C14:0	nd	7.4	4.1	0.8	9.8	nd	6.8	nd	nd	nd	nd
C15:0	nd	0.9	1.3	0.2	nd	nd	8.9	nd	166.1	107.4	10.8
C16:0	6.2	27.8	18.3	5.5	12.1	3.8	29.7	21.2	4407.8	1687.4	461.0
C17:0	7.6	nd	nd	nd	nd	nd	nd	1.68	103.6	61.2	17.3
C18:0	223.5	540.8	427.5	227.4	257.6	335.2	653.5	473.3	754.5	258.8	120.3
C20:0	nd	nd	nd	nd	nd	nd	34.6	nd	nd	34.2	43.4
SFA	235.4	577.0	451.2	234.0	279.5	338.9	733.5	496.2	5432.0	2149.0	652.8
C16:1	4.19	nd	8.5	1.4	1.14	nd	nd	9.4	1106.7	429.4	65.2
C18:1	45.3	32.39	28.1	13.2	4.5	59.6	85.7	45.0	4782.2	1639.6	648.6
MUFA	49.44	32.4	36.6	14.5	5.7	59.6	85.7	54.3	5888.9	2069.0	713.7
C18:3n-3	nd	nd	5.6	2.5	nd	nd	39.8	nd	1238.3	776.1	453.0
C20:3n-6	111.8	97.2	152.5	63.4	51.8	38.4	239.0	105.0	472.7	366.2	66.5
C20:4n-6	378.8	963.8	893.0	399.2	161.4	382.5	935.0	666.7	nd	87.3	nd
C20:5n-3	nd	nd	nd	nd	nd	nd	300.6	nd	569.3	232.5	148.7
C22:6n-3	26.2	nd	11.5	nd	nd	nd	nd	nd	263.6	92.0	57.2
PUFA	516.7	1061.0	1062.4	465.1	213.2	420.8	1515.3	771.6	2543.9	1554.1	725.5

* Adapted from [8]. ** Adapted from [23].

The total saturated fatty acid (SFA) concentration of Thai edible insects is relatively low, ranging from 233 to 5432 mg/100g. The main SFAs in Thai edible insects are stearic acid (18:0) and palmitic acid (16:0). Total MUFA content ranges from 6 to 5889 mg/100g (Table 4). Oleic acid (18:1) is the major MUFA found in all insects analyzed. According to the data from previous studies, insects differ in their fatty acid composition profiles. For example, in terricolous insects, ALA was found in three insects, while EPA and DHA were found in one or two out of eight insects. The reasons for insects containing long-chain PUFAs and different fatty acid compositions are linked to the diet and enzymatic activities of the insects [34]. For example, the diets of terriculous insects include grass or plants containing high ALA, whereas the diets of aquicolous insects include larvae and algae [41;42], providing only small amounts of long-chain PUFAs such as ARA and EPA. On the other hand, there is a report that dung beetles contain a substantial amount of EPA [8]. Dung beetles are coprophagous living on herbivore faeces. Their intake of nutrients includes the faeces of herbivores that consume plants containing ALA (grass and green leaves). Most insects are able to biosynthesize linoleic acid (18:2n-6). The lipids of aquatic insects and of some Antarctic beetles are high in C20 PUFAs [43]. Two reasonable explanations for why dung beetles contain EPA are first, that dung beetles consume EPAs via herbivore faeces which have been formed from ALA by endoenzymes of the herbivore, and second, that the dung beetle itself has endoenzymes that convert ALA in the herbivore faeces to EPA [8].

In summary, Thai edible insects are rich in protein and amino acids, especially the amino acids that are essential for the human body. The insects are a rich source of carbohydrates and lipids, especially high-quality fatty acids such as long chain omega-3 fatty acids [23].

POTENTIAL FOR WIDENING THE MARKET

Insects offer significant advantages in food production, especially when compared with traditional livestock production. There is considerable potential in widening the market for edible insects by incorporating insect protein in supplements, processed foods and animal feeds [44]. Thai edible insects are increasingly being farmed commercially in Northeast Thailand, expanding an industry that has sprung up since 1999 [45]. In instances where insects are traditional foods among a certain group, this fact can serve as a path to commercial development. Relevant insect species include the weaver ant, silk worm pupae and the bamboo caterpillar.

1. Weaver ants: A delicacy and an expensive food

Weaver ants (*Oecophylla smaragdina*) are a valued resource in some Southeast Asian countries since they are edible and considered a delicacy food. Among all Thai edible insects, the weaver ant is the most expensive in Thailand (9.5-12.7 US dollars, Table 1) because it has a unique taste and can be consumed in many ways. This ant has a protein content of 40-50% (dried weight) which is similar to other protein sources but they are a high-priced delicacy, being almost twice as expensive as beef or pork. The tradition of including *Oecophylla* ants in food and traditional medicine has been reported from different cultures in Thailand, India, Myanmar, Borneo, Philippines, Papua New Guinea, Australia and Congo [46]. In Thailand, this kind of ant has a long history of consumption, especially in rural areas. Larvae, pupae and the queen caste are used in a variety of Thai dishes and are available in local markets throughout these countries during the harvesting season. The ants can be consumed in many ways, such as in salads, fried or used as ingredients in soup (Table 2). They are also consumed raw together with herbs and spices as an entrée [47]. Food dishes made from weaver ants are shown in Figure 1.

In recent years, the weaver ants have been considered an expensive delicacy food since they are only collected from natural habitats. In some rural areas in Thailand, the income from ants accounts for almost 30% of the total household income for the ant collectors, besides providing their families with an animal food source [47].

Figure 1. Foods based on weaver ants

2. Bamboo Caterpillars

Although many insect species are consumed by Thai people, some insects are known and consumed only in particular geographic areas. The bamboo caterpillar is the second most expensive of the well-known edible insects of Thailand. It is mostly found in Northern Thailand where there are extensive bamboo forests. The edible larvae develop inside the bamboo stems and are collected for sale by local people. They are also preyed upon by woodpeckers. The bamboo caterpillar can be consumed in many ways, and frying is the favorite cooking method [48]. Some food dishes made from bamboo caterpillars are shown in Figure 2. Recently, fried bamboo caterpillars have been produced in canned form for sale nationally and worldwide.

Figure 2. Foods based on the bamboo caterpillar

3. Silk Worm Pupae

In many parts of the world, the silkworm pupae left after silk production are an important source of dietary protein for humans and animals. They may represent the oldest domesticated insect in the world, having been domesticated for thousands of years for silk production and as edible pupae [45]. In Thai rural communities, as in many Asian regions, silk worm pupae have been known to provide a valuable source of protein, minerals and vitamins, as well as being a tasty food [49]. Silk worm pupae are rich in protein and a good source of fatty acids, especially omega-3 fatty acids (18:3, n-3). Silk worm pupae can be consumed in many ways, such as fried or used as ingredients in soup. They are also prepared by simple drying under the sun or solar drying [50]. Food dishes made from silk worm pupae are shown in Figure 3. Silk production has an enormous potential in Thailand provided it is made available to rural people, especially women, and if its marketing is organized independently. It can serve as an excellent means of employment generation and augmentation of income. Silk worm pupae are widely offered in local markets and restaurants. In Thailand, silk worm pupae powder is used to fortify rice crackers and some other snacks. In addition, the use of silk by-products has been extended to cosmetics.

Figure 3. Foods based on silk worm pupae

FOOD SAFETY FOR THAI EDIBLE INSECTS

Insects are traditional foods in many cultures and play an important role in human nutrition. The insect has been a good nutritional food source, especially for fat and protein. Future attempts to take advantage of this resource should include how to promote Thai insects as a nutritional food source. Information on the toxicity and food safety of insects is needed to satisfy consumer concerns. In general, many insects are herbivorous and less problematic than omnivores. But pesticide use can make insects unsuitable for human consumption. Herbicides can accumulate in insects through bioaccumulation and this may pose a problem since edible plants have been consumed by the locusts themselves. For example; in Mexico, the grasshopper *Sphenarium purpurascens* is collected for sale as food, but its suitability as a safe food is controlled by possible contamination with organophosphorus pesticides [51].

FUTURE TRENDS

Thai edible insects not only serve as a source of food from paddy fields, upland forests and natural pond areas of Thailand, but also reflect rich cultural traditions and a diverse biological resource. As Thai edible insects are good resources for generating income, there is likely to be an increase in the numbers of Thai edible insects collected. However, increases in demand could lead to competition and over exploitation. Forest fragmentation and habitat loss are increasing because of land development in Thailand. These trends may well lead to decreases in insect diversity as well as in populations of other native fauna and flora. Many Thai edible insect species are collected in the wild. The quantity collected and the species found depend on season and location. However, several Thai entomologists, as well as local people, have recently developed techniques for mass rearing on a commercial scale for several edible insect species such as silk worms, crickets, ants and bamboo caterpillars. If such insects are to be used in a sustainable manner, appropriate commercial use depends on people's awareness of the insects' habitats and related factors. Furthermore, product development for adding value to edible insects is necessary.

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