Wild-harvested edible insects

Apart from farmed edible insects like crickets and palm weevil larvae, other edible insect species such as silkworm pupae, grasshoppers, weaver ants and bamboo caterpillars are also popular food items and can be found in every market.

Grasshoppers, weaver ants, giant water bugs and bamboo caterpillars are the most popular wild edible insects consumed. Grasshoppers are collected in the wild, but mainly imported from Cambodia; weaver ants and bamboo caterpillars are harvested in the wild seasonally.

Bamboo caterpillar (*Omphisa fuscidenttalis* Hampson, Family Pyralidae)

Known in Thai as rod fai duan or 'the express train' the larvae live inside bamboo plants for around ten months. It feeds on 11 species of *Dendrocalamus* and *Thyrsostachys* bamboo. The number of larvae depends on the size of the bamboo culms (Kayikananta 2000; Leksawasdi 2001).

Collecting techniques

Bamboo caterpillars are mainly collected in the north of Thailand. Bamboo caterpillars were traditionally collected by cutting down entire bamboo clumps to harvest the caterpillars. This approach was destructive and sometimes wasteful of bamboo material. More recently a less invasive collection method has been tried. Sustainable collection without cutting bamboo trees is starting to be practised by local people. Mr.Piyachart, a collector of bamboo caterpillars from the wild, was interviewed in Chiang Rai Province to learn about his sustainable collecting method. The adult caterpillar exits, after pupa emergence, from a hole at the base of the bamboo stem. The first or second internode is examined to reveal the damage caused by the bamboo caterpillar and its location. The denseness of an internode is a clue to indicate the presence of bamboo caterpillars. The harvesting of bamboo caterpillars is conducted by slicing the specific infested internode to obtain the larvae without cutting the whole plant. Collection is carried out by cutting a rectangular hole approximately 9 x 13 square centimetres in size at specific internodes hosting the bamboo caterpillars.

The female moth lays a mass of 80 to 130 eggs on the sheaths at the base of bamboo shoots. After hatching, the young larvae bore an entrance hole mostly from the fifth to the tenth internodes. The larvae live and eat inside the bamboo shoot, usually a young shoot, on the upper part, until they are 45 to 60 days old, when they move down to congregate in the internode with the existing egress point for another eight months. The Royal Forest Department recommends that the best time for collecting bamboo caterpillars is around January to April when bamboo caterpillars can be obtained from the specific internode and the infested bamboo culm can be harvested for later utilization (Kayikananta 2000).

Generally, the infested bamboo culms are stronger than the non-infested ones because the wood cells are small and dense, making them stronger and heavier than normal bamboo. They can be utilized to make bamboo handicrafts and construction poles.

Rearing technique

The best practice for farming bamboo caterpillars has yet to be developed. Currently, the Royal Forest Department had developed management rearing techniques for bamboo caterpillars (Kayikananta 2000). Two management methods are recommended. The first is controlling mating in a nylon net cage covering the bamboo shoot and the second is releasing moths for natural mating into the bamboo plot. The latter is best because it is easy and convenient.

Economics and marketing

According to farmer groups at Tambon Waree, Chiang Rai Province, each year about 500 kilograms of bamboo caterpillars are harvested and sold at THB200-250/kilogram to buyers who come to their villages.

Mr Jaturong, an edible insect entrepreneur, is one of the biggest buyers of bamboo caterpillars. His company brand is 'Mae Urai, Edible Insect'. Each year he buys at least 20 000 kilograms of bamboo caterpillars from villages in the north of Thailand; 10-20 percent comes from neighbouring countries such as Lao PDR and Myanmar. The product is packaged in both uncooked frozen packs and ready-to-eat boxes (deep-fried beforehand). The uncooked frozen packs are distributed throughout Thailand via the Makro wholesale supermarket chain. On average, 1 000 kilograms are sold each month at THB365/kilogram. The ready-to-eat (cooked) bamboo caterpillars are packed in plastic boxes containing 100 grams and sell at THB130 in retail shops. Each month

around 3 500 to 4 000 boxes are sold. Recently, the company has developed a new product line of cooked bamboo caterpillars sealed in a container that can be heated in a microwave oven before eating.

Opportunities and constraints

Bamboo caterpillars are one of the most popular edible insects and the selling price is still quite high compared to other edible species. A rearing technique has been developed, although it is still based on semi-natural habitat and still needs bamboo as the food source. However, with proper management of semi-natural farming and harvesting, bamboo caterpillars can become a more popular edible insect and help with income generation for local people. The area of bamboo plantations could be increased for farming purposes – an indirect contribution to environmental conservation.

Lack of knowledge or only basic understanding about the biology, ecology and habitat of these caterpillars by local harvesters presents a risk to the ongoing availability of the species. Therefore, proper management and harvesting techniques for sustainable use of this insect are urgently needed for local people; mainly ethnic groups in the north of Thailand.

As the bamboo caterpillar is widely consumed and in demand, a simple and efficient breeding technology for bamboo caterpillars at the farm level as well as imported product processing should be further investigated and developed.

Weaver ant (*Oecophylla smaragdina* Fabricius, Family Formicidae)

Weaver ants are known locally as 'red' ants or mod-daeng and are a popular delicacy. The ant workers construct nests by weaving together leaves using larval silk. Many ant colonies can be found on one tree.

Weaver ants are predominantly found in the northeast and have been interlinked with the way of life of people in this region for a long time. Traditional local folk songs and dances have included stories of red ant egg harvesting. Red ant eggs (the larval and pupal stage), or khai mod-daeng are popular food. Pupae and adults are also eaten. The most popular dishes, particularly in the northeast, are omelet mixed with red ant eggs and Thai red ant egg salad (yum khai mod-daeng).

Usually weaver ants are harvested from trees in the wild. However, some

farmers can breed and maintain weaver ant colonies in their own gardens on mango trees. The colonies can be maintained and expanded if their host trees are protected from predators and have good access to water. The weaver ants need water to produce acetic acid.

A method to propagate ant nests in mango orchards is the use of overhead ant highways that link the trees of the orchard. These ant highways help the ants to conserve energy by not needing to leave their trees and also protect them from ground based predators. Consequently nest multiplication is accelerated. The highways are made from any type of rope, except plastic material, but rattan canes are preferred.

Collecting techniques

In north and northeast Thailand the season for weaver ants' harvesting usually occurs once a year during the dry season between February and May. During this period the arboreal nests of the weaver ants are full of eggs, larvae and pupae. In Petchabun Province the season occurs from January to May and three crops are obtained annually.

Harvesting is undertaken using a long bamboo pole with a bag or basket attached with strings to the tip. A hole is poked into the nest with the tip of the pole and it is shaken so the larvae and pupae fall down into the bag. Then the bag is poured onto a plate or container and some rice or tapioca flour is added to prevent the ants from climbing up to bite the collector. A branch is put on the plate for adult ants to climb back up the branch and it is whipped against a tree to release the adult ants. The remaining larvae and pupae are removed for consumption (Lewvanich *et al*. 1999).

Economics and marketing

Information on production and marketing of weaver ants is limited to individual cases. Currently, the market price for weaver ant eggs is round THB250-500/kilogram depending on the period and location. When the season is nearly over, the price will be high. Usually 1-2 kilograms of weaver ants can be collected in the wild each day although some collectors can collect 5-8 kilograms/day. About 300-400 grams of larvae and pupae per nest can be harvested. On average one collector can earn THB250-500/day.

The income for weaver ant sellers at markets in the northeast and north (based on interviews) is around THB 1 200-3 000/day with around 5-10 kilograms of weaver ants sold per day (on average 5 kilograms/day).

One wholesaler at Talad Thai market in Bangkok, which is one of the biggest edible insect markets, can sell around 30-40 kilograms/day and net profit is around THB2 000-2 500/day.

Weaver ants can generate good income for both collectors and sellers but weaver ant harvesting is still a sideline occupation. Income from their collection exceeds normal farm income from rice or cassava production for example. However, there is only a short harvesting period of three to four months per year starting in February. Weaver ants are sold as fresh produce in markets everywhere, particularly in the north and northeast during the harvesting period in the dry season. Canned weaver ants in brine are also sold, a common practice which preserves the product for a long time, ideal for export to overseas markets.

Opportunities and constraints

Weaver ants are very popular and consumer demand is higher than the natural supply. According to local people, numbers of weaver ants have been decreasing and they are more difficult to find in the wild. Decreasing populations are a negative impact on ecological systems because ants are predators and perform many ecological roles that are beneficial to humans, including the suppression of pest populations. Weaver ants were first used for biological control of citrus pests in China, and are used in mango and cashew plantations in Australia (Peng *et al.* 1999; Peng and Christian 2004-2007).

Weaver ants can easily be semi-farmed in home gardens by feeding with food scraps and sufficient water; colonies can be expanded with proper management. However, biological and ecological aspects, particularly finding the queen of the colony or creating a new queen for the colony as well as preferred trees and ecological habitat need proper understanding. Weaver ant queens do not live in the large nests seen lower down in the tree host. The queen is found in a small nest at the highest point of the tree where it is difficult to reach. A colony on a tree without a queen will eventually die.

Giant water bug (*Lethocerus indicus* Lep.-Serv., Family Belostomatidae)

The giant water bug is native to Southeast Asia. It is a popular edible insect, known by locals as malaeng da na and is consumed in almost all parts of Thailand. The whole bug except the wings is eaten. It can be grilled or fried or used as an extract in sauces to make Nam Phrik Mangda, a type of chili sauce. Usually the male is preferred as the male has a scent gland that can produce a strong distinctive smell.

Collecting techniques

Giant water bugs live in still water, swamps and rice paddies. During the rainy season (May to August) they come out of the water and are attracted to lights, especially blue neon lights. One common method for catching them in a field is to set up a blue neon light with a long bamboo pole 2-3 metres high. A water container is placed on the ground to collect the bugs that fall down. Fishing nets are also used to harvest them from swamps and ponds (Lewvanich et al. 1999).

Economics and marketing

Giant water bugs are predaceous insects and usually sensitive to polluted environments. Although the giant water bug is a very popular edible insect among Thai people, these days the population of this species is declining due to environmental and habitat changes and pollution. Large numbers of giant water bugs are bought from neighbouring countries like Cambodia and Myanmar.

Due to high demand in the market, the price is high and increasing year by year. In the last few years one male would cost THB10. However the price rose to THB15 in 2011. Females are cheaper and sold at THB8-10 each.

Recently giant water bugs have been sold in frozen 10-bug packages in wholesale chain supermarkets throughout the country (for example Makro supermarket). Male bugs cost THB130/pack while females cost THB65/pack.

One wholesaler of giant water bugs at the Kalasin edible insect market in the northeast indicated that each day at least 3 000 bugs are sold at THB10-13/bug, mainly males. The bugs are bought from Cambodia through the edible insect market near the Cambodian border.

Opportunities and constraints

Farming is quite difficult and laborious because this species is predaceous and cannibalistic when populations are crowded.

Recently a researcher at Rajamangala University of Technology Isan in Sakon Nakhon Province (Sanewong Na Ayudtaya 2011) has developed a breeding method to farm the giant water bug. If this technology can be developed for farming on a commercial scale, this will help to reduce the massive harvesting of giant water bugs from the wild which impacts ecosystems by lowering predatory populations.

Grasshoppers (Order Orthoptera)

Many species of Orthoptera or grasshoppers are edible. In Thailand, they include *Patanga succincta*, *Locusta migratoria*, *Acrida* sp., *Cyrtacanthacris tatarica* and *Oxya japonica japonica* (Thunb.) (Hanboonsong *et al.* 2001; Rattanapan 2000). All of them are pests of economic crops such as maize and rice. Grasshopper species, particularly *Patanga succincta* and *Locusta migratoria*, used to be one of the major pests of maize and rice. Today they have become one of the most popular edible insects since they were introduced for human consumption by entomologists – a campaign to eat grasshoppers had been launched because control efforts had been unsuccessful. For example, in 1983 this was launched by local officials and villagers in Prachin Buri Province collected more than 10 tonnes for use as food (Lewvanich *et al*. 1999).

Collecting method

Grasshoppers are collected in paddy or maize fields by using a net, a piece of cloth or by hand at night or in the early morning as low temperatures make them inactive. Before consumption, the intestines and wings are removed and the torso is washed in water. Deep-frying is a popular way to cook them.

Economics and marketing

Wild collection of grasshoppers is rarely witnessed in Thailand. Most edible grasshoppers sold in Thai markets come from Cambodia. Approximately 170 tonnes of grasshoppers are imported annually for retail at Rong Kluea market at the Cambodia border in Sa Kaeo Province (Ratanachan 2009). Imported grasshoppers are sold through a network of fresh markets throughout the country by traders and intermediaries. They are purchased by street food vendors for sale in night

markets and food stalls all over Thailand.

Grasshoppers are also sold in frozen packages at all 51 Makro wholesale supermarkets throughout Thailand. Each day at least 10 kilograms of grasshoppers are sold at each branch for THB354/kilogram (for Bombay locust).

Opportunities and constraints

Grasshoppers are one of the most popular edible insects eaten by Thai people. Entomologists at Khon Kaen University have successfully developed a breeding technique to mass rear them, but the technology still cannot be expanded on a commercial scale as it is not an economically viable way to farm this type of insect. It has almost a year-long life cycle and still requires its natural food for feeding.

Nowadays many new species of grasshoppers are collected from the wild. Many of them are still unknown and have not yet been identified or recorded. The diversity of grasshopper species caught for consumption is wider than in the past.

Figure 11. Wild-harvested edible insect species: (a-b) bamboo caterpillars, (c) wasps and (d) water scavenger beetles

Figure 12. Wild-harvested edible insect species: (a-c) weaver ants, (d) grasshoppers and (e) dung beetles

Business and market channels

It has been difficult to determine the extent of wild harvesting and farming in Thailand because this is conducted at two levels: subsistence (use of insects for domestic consumption or as an additional source of income, mainly harvesting wild species) and commercial producers. There is no overriding group that oversees the industry, so obtaining data at any level (provincial or national) is difficult. The situation is complicated in the case of wild-harvested insects because many are imported from adjacent countries.

Subsistence and commercial use

It is difficult to get reliable information about the extent of insects gathered as subsistence food by individual farmers or sold for income generation.

Good data are available for some commercial enterprises. The production and marketing channels, cost and income can be determined in some cases. However, it is difficult to determine how information obtained at the local level can be extrapolated to the provincial or national level because the extent of edible insect trade varies considerably across Thailand, and the nature of the operations also varies.

The trading channels for edible insects are shown in Figures 15 and 16 (wild harvested insects) and Figures 8 and 10 (farmed insects). In both cases, the villager is either the collector or a farmer who keeps insect colonies.

In the case of wild-harvested insects, the collectors may use the insects themselves, sell them directly to the public or sell to an intermediary (wholesale buyer). This can occur in Thailand, but is more likely to occur in adjacent countries. The wholesale buyer will visit individual collectors and purchase the insects or the collectors will directly bring insects to the wholesale buyer's venue. They are then sold to a wholesale market (for example at the Rong Kluea market on the Cambodian border).

Once the insects reach the wholesale buyer, the scenario is similar for both wild-harvested and farmed insects. They are stored in a cool store as frozen packages and sold to distributors, who in turn sell to the retailers (generally market stall operators). There can be variations in trading channels. An intermediary may sell stock directly to distributors or retailers.

Edible insect markets

Both fresh and cooked edible insects can be found in all types of markets at provincial or district levels. Several well-known edible insect wholesale markets are Rong Kluea in Sa Kaeo Province (the biggest edible insect market near the Cambodian border), Klong Toey market (Bangkok), Talad Thai (Bangkok) and Jatujak market (Bangkok) — this market sells mainly mealworms for pet feed). Talad Kaset in Kalasin Province is one of the largest wholesale markets for distribution of edible insects in the northeast. Mainly farmed crickets, silkworm pupae, giant water bugs and grasshoppers are sold there.

Markets can be divided into three groups based on income generated from selling insects. Large markets are Rong Kluea and Talad Thai, which have an average monthly income of approximately THB300 000. Medium-size markets are Jatujak and Klong Toey markets in Bangkok, with an average monthly income of around THB200 000 to 250 000. Small insect markets are located in a scattering of submarkets in provinces in the northeast such as Warin Chamrab market in Ubon Ratchatani near the Lao border; also Kalasin and Loei provincial markets. Average monthly income ranges from THB50 000 to 80 000.

Storage for edible insects

Most edible insects sold in markets are wild harvested and they are available seasonally. Therefore, the wholesalers usually keep insects in cold storage and in some cases, like giant water bugs, are preserved with salt for prolonged storage. There are two types of cold storage: (1) plastic tanks in which the products are covered with ice cubes (temporary storage for two to three days) and (2) long-term storage in cold storage rooms at -18 °C to -20 °C (products can be kept for one to two years). Some wholesalers have their own cold rooms with up to 300-tonne capacity. However, this type of storage has both positive and negative aspects. Proper cold storage will prolong the usable life of the insects and also is an important food safety factor. On the negative side, it may encourage overharvesting of insects that are very seasonal. For example weaver ants – collectors may be tempted to collect more than is ecologically sustainable in order to generate more income. The wholesaler can store the weaver ants and sell them at times when they are generally not available.

Imported insect products

Only a few species can be farmed such as house crickets, palm weevils and

mealworms. Recently, giant water bug farming technology has also been developed but it has not been very successful. Other species such as grasshoppers, bamboo caterpillars and giant water bugs are still wild harvested and imported from neighbouring countries to Rong Kluea market. Grasshoppers, black scorpions and giant water bugs are imported from Cambodia. Silkworm pupae are produced in the northeast where the silkworm industry is located. The supply of silkworm pupae consumption is still not sufficient. Approximately 270 tonnes per year are imported from China by wholesalers at Rong Kluea market. It has been reported that about 800 tonnes of edible insects are annually imported from Cambodia, Myanmar, Lao PDR and China to Rong Kluea market (Ratanachan 2009). The top five imported insects are silkworm pupae, ground crickets, leaf-eating grasshoppers, mole crickets and giant water bugs. The economic value of imported insects is estimated at around THB40 million per year.

Figure 13. Edible insects are sold in various markets

Figure 14. Edible insect markets and businesses: (a) wholesale sellers at Rong Kluea market, (b) frozen packages in a supermarket, (c) precooked bamboo caterpillars on sale at a souvenir food shop and (d) precooked bamboo caterpillars for microwaving

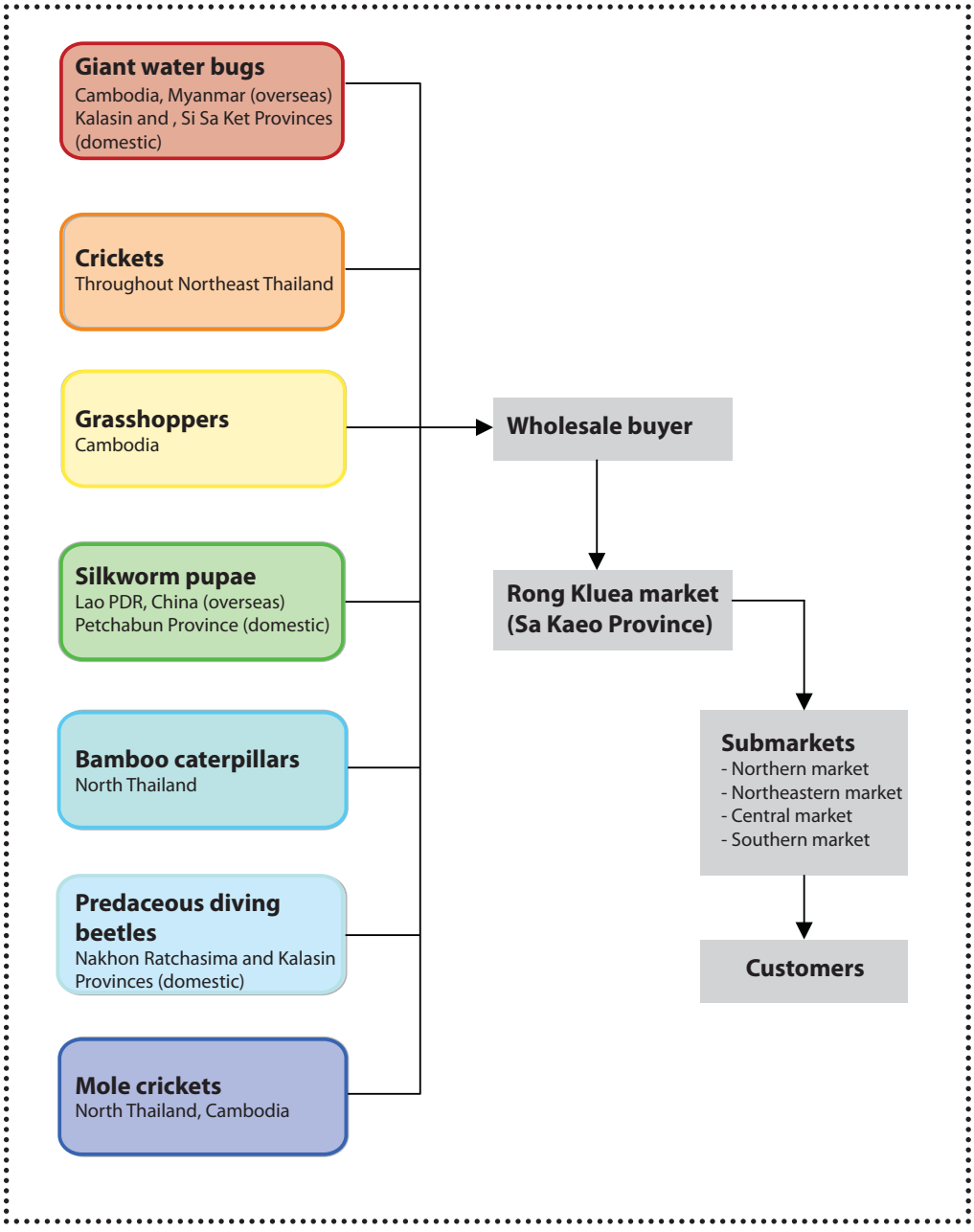

Figure 15. Collection and distribution market chains for edible insects

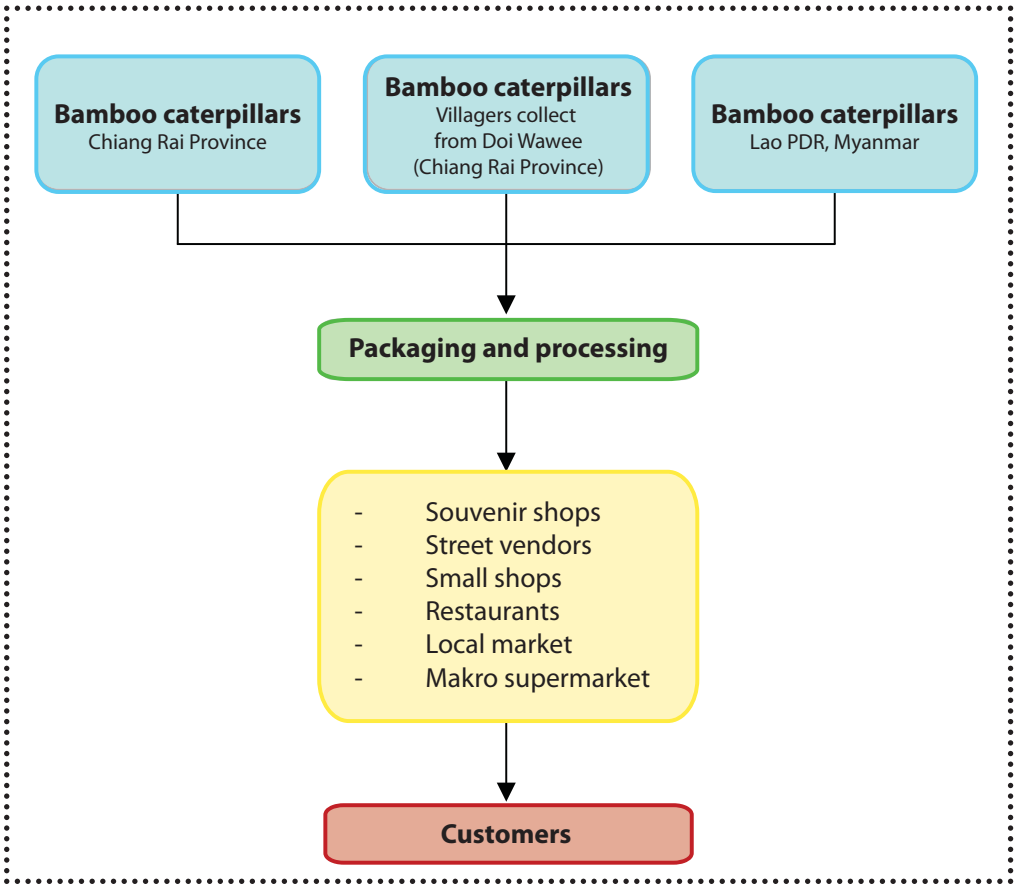

Figure 16. Bamboo caterpillar collection and distribution chain

Recommendations

The eating and trade of edible insect species in Thailand are very common and developing rapidly. Edible insect species are obtained from both wild harvesting and the farming of a few species. But while the sector has developed rapidly in the last 15 years, it is still informal and ad hoc in structure and practice. This is an industry where commercialization has outpaced academic research for species suitable for farming and best farm practices. Consequently, many questions remain unanswered on such matters as management, breeding, hygiene and marketing issues.

However, the edible insect industry has much potential for providing protein sources in the future and for income generation among Thai farmers. Development and creation of intensive insect farms on small and large scales could take the pressure off wild populations of insects in forest areas.

Wild harvesting and insect farming

The edible insect industry was founded on the wild collection of various species from forest areas around villages. Today several species are very popular with consumers and some wild species are becoming increasingly scarce. This has resulted in the need to import some species such as giant water bugs, bamboo caterpillars and grasshoppers. For species such as grasshoppers, as long as the food crops they consume are planted, wild harvesting is unlikely to reduce populations significantly so wild collection can still be considered sustainable.

There is concern that the loss of other species from local environments could occur from collection pressure, which could have undesirable effects *vis-à-vis* pest species they may control.

In the future if the focus of the sector moves away from wild collection to farm-based industry, this will take pressure off wild populations. It is also important to note that insects collected from the wild come with the associated hazard of no quality control and risks such as insecticide contamination. Therefore, farmed insect sources are preferable from a food safety perspective.

To date, farming technology and practices have only been developed for a few species such as crickets, palm weevils and mealworms so there is an urgent need to invest in research and development on farming techniques for other species that are consumed. The Thai Government

currently injects little research funding into insects as a food source compared with other agricultural industries.

Knowledge gaps

One of the problems facing the sector is that it has developed ahead of academic research. As a result farmers encounter problems for which academic and extension workers may have no solutions.

Universities should be aware of this emerging sector as a future career path for students. In the future, entomology courses will not only focus on plant protection but also on commercial insect production.

Further research is urgently needed in all stages of the production of edible insects and particularly postharvest processing. Currently, harvested insects are sold with little processing. There is potential to develop processes for preservation but as yet little work has been done. Proteins extracted from edible insects are likely to be of interest to food technologists and possibly the pharmaceutical industry.

Moreover, information about wild harvesting of insects is limited and incomplete. Consequently, for many species we cannot be sure if collection pressure is at sustainable or unsustainable levels. In addition, little work has been done on best practices or improved methods of wild collection.

Another knowledge gap concerns the scope and span of the edible insect market in Thailand as many production and consumption data are not recorded. Why this information is not available is because the notion of 'insects as food' is not included in national food data surveys conducted by various government agencies.

Capital and investment issues

The capital cost of setting up an insect farm is not great, but may still be a constraint for some otherwise motivated farmers. At present, it is difficult to borrow funds at a reasonable rate for setting up an enterprise. Some finance institutions are disinterested in lending as they are unaware of the economics involved. Cricket farming has been encouraged in Thailand through the SMCE scheme under the Ministry of Agriculture and Co-operatives. However, villages involved in this scheme have minimal involvement in other edible insect species such as palm weevils and the operation of the SMCE is not truly representative of a cooperative in terms of profit distribution.

Ideally, the lead should be taken by government agricultural lenders, as they can influence the development and location of insect farms based on their lending policy. But to date, the agriculture banks are mainly unaware of the insect-farming industry and its potential.

To raise the profile of insect farming, ideally an external organization such as FAO needs to raise the issue with regional governments and potential leaders. Once awareness and understanding of the industry's potential as a new or alternative supplier of food protein are generated, funding is likely to flow into research, processing and banking agencies associated with the new industry.

The other possible boost to the industry could come from venture capital from a commercial operator to fund research into processing and other aspects of insect production.

Public education and marketing

There is a need to raise the profile of edible insects among the public and for farmers who may wish to become involved. Some promotion has been done already by the government for cricket farming in the SMCE, but more widespread marketing and promotion of this new sector would be beneficial to create demand and raise interest among potential farmers and consumers.

Although many people in Thailand consume insect products, the market is still relatively small. There is great potential to increase consumption demand through marketing campaigns aimed at segments of the population who are currently unaware of edible insect products. Some processing and product development may be needed, but if undertaken along with clever advertising, both demand and prices could rise for the producers. Instant products, new foods and microwavable items will all appeal to young and middle class consumers.

Policy-maker awareness

As mentioned earlier, scant data on the edible insect industry are gathered by Thai Government agencies. Consequently, the extent and potential of the insect food industry is largely overlooked by policy-makers. There is a need to raise awareness of the growth and potential of the edible insect sector amongst policy-makers to promote and guide future development and channel funding into research into key areas such as best management practices, food safety issues, promotion and international trade.

Conclusion

The collection of edible insects in Thailand is an historic practice, but their farming is relatively new. Incomplete information nationwide indicates a growing and healthy market. However, knowledge gaps regarding sustainable wild collection and best management practices for farmed insects are a major risk for the industry. The current lack of government involvement in the promotion of the industry is seen as a major weakness. Edible insects have huge potential as a protein source with significance both domestically and internationally in helping to feed the burgeoning global population.

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Appendix 1. Insect species eaten in Northeast Thailand (source: Rattanapan 2000)

Order/Family/common name	Scientific name
COLEOPTERA	
Buprestidae	
Metallic wood-boring beetles	*Sternocera aequisignata* Saunders
	S. ruficornis Saunders
Cerambycidae	
Long-horned beetles	*Aeolesthus* sp.
	Apriona germai Hope
	Aristobia approximator Thomson
	Dorysthenes buqueti Guérin-Méneville
	Plocaederus obesus Gahan
	P. ruficornis Newman
Curculionidae	
Snout beetles	*Arrhines hiruts* Faust
	Arrhines spp.
	Astycus gestvoi Marshall
	Cnaphoscapus decoratus Faust
	Episomus sp.
	Genus near *Deiradorrhinus*
	Hypomeces squamosus F.
	Pollendera atomaria Motschulsky
	Sepiomus aurivilliusi Faust
	Tanymeces sp.
	Rhynchophorus ferrugineus Olivier
Hydrophilidae	
Water scavenger beetles	*Hydrobiomorpha spinicollis* Eschscholtz
	Hydrophilus bilineatus Redtenbacher
	Sternolophus rufipes F.
Dytiscidae	
Predaceous diving beetles	*Erectes stiticus* L.
	Cybister tripunctatus asiaticus Sharp
	C. limbatus F.
	C. rugosus MacLeay
	Hydaticus rhantoides Sharp
	Laccophilus pulicarius Sharp

	Copelatus sp.
	Rhantaticus congestus Klug
Scarabaeidae	
Rhinoceros beetles, elephant beetles	*Xylotrupes gideon* L.
	Oryctes rhinoceros L.
June beetles	*Adoretus* spp.
	Agestrata orichalca L.
	Anomala anguliceps Arrow
	A. antique Gyllenhal
	A. chalcites Sharp
	A. cupripes Hope
	A. pallida F.
	Apogonia sp.
	Chaetadoretus cribratus White
	Holotrichia spp.
	Maladera sp.
	Pachnessa sp.
	Protaetia sp.
	Sophrops absceussus Brenske
	S. bituberculatus Moser
	S. rotundicollis T. Ihto
	Sophrops spp.
	Sophrops species mean *abscessus* Brenske
	Tribe Sericini 7 spp.
Dung beetles	*Aphodius (Pharaphodius) crenatus* Harold
	A. (Pharaphodius) marginellus F.
	A. (Pharaphodius) putearius Reitter
	A. (Pharaphodius) sp.
	Cathasius birmanicus Lansberge
	C. molossus L.
	Copris (s.str.) *carinicus* Gillet
	C. (s.str.) *nevinsoni* Waterhouse
	C. (Paracopris) punctulatus Gillet
	C. (Microcopris) reflexus F.
	C. (Paracopris) sp.
	Gymnopleurus melanarius Harold
	Heliocopris bucephalus F.
	Heteronychus lioderes Redtenbacher
	Liatongus (Paraliatongus) rhadamitus F.

	Onitis niger Lansberge
	O. subopagus Arrow
	Onthophagus orientalis Harold
	O. avocetta Arrow
	O. bonasus F.
	O. khonmiinitnoi Masumoto
	O. papulatus Boucomont
	O. sagittarius F.
	O. seniculus F.
	O. ragoides Boucomont
	O. tragus F.
	O. tricornis Weidemannn
	O. trituber Weidemannn
	Onthophagus sp.
HEMIPTERA	
Belostomatidae	
Water bug	*Diplonychus* sp.
Giant water bug	*Lethocerus indicus* Lepeletier & Sepville
Coriedae	
Leaf-footed bug	*Anoplocnemis phasiana* F.
Stink bug	*Homoeocerus* sp.
Gerridae	
Water strider	*Cylindrostethus scrutator* Kirkaldy
Nepidae	
Water scorpions	*Laccotrephes rubber* L.
	Ranatra longipes thai Lansbury
	R. varripes Stal.
Notonectidae	
Backswimmers	*Anisops barbutus* Brooks
	A. bouvieri Kirkaldy
Tessaratomidae	
Stink bugs	*Pygopaltys* sp.
	Tessaratoma papillosa Drury
	T. javanica Thunberg
ODONATA	
Aeshnidae	
Darner (nymph)	*Aeshna* sp.
Coenagrionidae	
Narrow-winged damselfly (nymph)	*Ceriagrion* sp.

Corduliidae	
Green-eyed skimmer (nymph)	*Epophtalmia vittigera bellicose* Lieftinck
Libellulidae	
Common skimmer	*Rhyothemis* sp.
HYMENOPTERA	
Apidae	
Bees	*Apis dorsata* F.
	A. florea F.
Formicidae	
Weaver ants	*Oecophylla smaragdina* F.
	Carebara castanea Smith
Vespidae	
Wasps	*Vespa affinis indosinensis* Perez
ORTHOPTERA	
Acrididae	
Short-horned grasshoppers	*Acrida cinerea* Thunberg
	Acrida sp.
	Chondacris rosea DeGeer
	Chortippus sp.
	Cyrtacanthacris tatarica L.
	Ducetia japonica Thunberg
	Locusta migratoria L.
	Mecopoda elongate L.
	Oxya sp.
	Parapleurus sp.
	Patanga japonica Bolivar
	P. succincta L.
	Shirakiacris shirakii
	Trilophidia annulata Thunberg
Atractomorphidae	
Short-horned grasshopper	*Atractomorpha* sp.
Catantopidae	
Short-horned grasshopper	*Ratanga avis* Rehn et Rehn
Gryllidae	
Crickets	*Teleogryllus testaceus* Walker
	T. mitratrus Burmeister
	Teleogryllus sp.
	Modicogryllus confirmatus Walker
	Brachytrupes portentosus Lichtenstein

	Gryllus bimaculatus DeGeer
	Gryllus sp.
	Gymnogryllus spp.
	Pteronemobius sp.
	Velarifictorus sp.
Gryllotalpidae	
Mole cricket	*Gryllotalpa africana microphtalma* Chopard
Mantidae	
Mantids	*Tenodera ariddifolia sinensis* Saussure
	Mantis religiosa L.
Tettrigidae	
Pygmy grasshopper	*Euparatettix* sp.
Tettigoniidae	
Long-horned grasshoppers	*Euconocephalus incertus* Walker
	Conocephalus maculatus LeGuillou
	Conocephalus sp.
	Onomachus sp.
	Pseudophyllus titan White
	Homeoxipha sp.
ISOPTERA	
Termestidae	
Termite	*Macrotermes gilvus* Hagen
LEPIDOPTERA	
Bombycidae	
Silkworm moth	*Bombyx mori* L.
Hesperidae	
Skipper	*Erionata thrax thrax* L.
Pyralidae	
Bamboo caterpillar	*Omphisa fuscidentalis* Hampson
HOMOPTERA	
Cicadidae	
Cicadas	*Chremistica* sp.
	Dundubia sp.
	Orientopsaltria sp.
	Platylomia sp.

Appendix 2. Insect species eaten in upper Southern Thailand (source: Lumsa-ad 2001)

Order/Family/common name	Scientific name
COLEOPTERA	
Curculionidae	
Snout beetles	*Hypomesus squamosus* F.
	Rhynchophorus ferrugineus Olivier
Hydrophilidae	
Water scavenger beetles	*Hydrophilus* sp.
Dytiscidae	*Cybister* sp.
Predaceous diving beetles	
Scarabaeidae	*Apogonia* sp
June beetles	*Lepidiota stigma* F.
HEMIPTERA	
Belostomatidae	
Giant water bug	*Lethocerus indicus* Lepeletier & Sepville
Cicadidae	*Dundubia intermerata* Walker
ODONATA	
Libellulidae	
Common skimmer	*Rhyothemis* sp.
HYMENOPTERA	
Apidae	
Bees	*Apis florae* F.
Formicidae	
Weaver ants	*Oecophylla smaragdina* F.
Ants	*Carebara lignata*
Vespidae	
Wasps	*Vespa affinis indosinensis* Perez
ORTHOPTERA	
Acrididae	
Short-horned grasshoppers	*Chondacris rosea burnneri* Uv.
Gryllidae	
Crickets	*Teleogryllus testaceus* Walker
	Gryllus bimaculatus Degeer
Gryllotalpidae	
Mole cricket	*Gryllotalpa africana* Pal
LEPIDOPTERA	
Bombycidae	*Bombyx mori* L.
Hesperiidae	*Erionota thrax thrax* L.

Six-legged livestock:

edible insect farming, collecting and marketing in Thailand

"How to feed a growing world population expected to reach 9 billion people by 2050?"

The traditional answer would be to develop higher yielding grain cultivars and intensify production and inputs.

But for those looking "outside the box" some of the world's under-utilized foods potentially offer even greater opportunities.

Edible insect species offer significant potential to contribute to feeding the world's expanding population. Insects offer several advantages: they are highly nutritious, rich in protein, vitamins and minerals; they are highly efficient at feed conversion; and they taste great!

This publication provides unique insights into the edible insect industry in Thailand – one of the few countries in the world where commercial production of food insects is already a reality. This detailed review offers planners, development workers, researchers, students and wannabe farmers valuable information on the Thai experience, and just maybe…. your future food.

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