SUSTAINABILITY AND TRADITIONAL LIVELIHOOD SYSTEMS IN NORTHERN LAO PDR WITH AN EMPHASIS ON EDIBLE INSECTS

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This article examines traditional sustainable practices in Northern Lao PDR vis-à-vis edible insects arguing that sustainable and traditional practices can go hand in hand. Political ecology, traditional ecological knowledge, and biological aspects of the agroecosystem are discussed to exemplify the complexity of the system. Data on insect availability and selling prices in five markets across the region in December 2016, reveal Lao PDR's economic potential and its unique position in regard to taking advantage of insect-eating traditions. I cite international research about the low environmental costs of raising or collecting edible insects, their rich nutritional content, and other benefits and issues of insects as food sources. Finally, I argue that traditional insect knowledge and collection has the potential to be an economic boon, benefiting farming households in the uplands by maintaining traditional agroecosystems while at the same time preserving traditional lifestyles with dignity.

Introduction

There are more than 750,000 documented insects in the world (Braack 2010). Of these, more than 2,000 insects are edible, and 80 percent of the world's cultures eat them (Tabassum-Abbasi et. al. 2016; van Huis et.al. 2013). Nutrients from consuming insects may have assisted *Homo sapiens'* brain development and strengthened tooth enamel (Tommaseo-Ponzetta 2005; Tabassum-Abbassi et.al. 2016:1756-1757). Historically, humans have been entomophagous species, with many insects considered food for royals and elite classes or for special events. For example, Aztec kings ate *ahuahutle* (Mexican caviar—still eaten today—made up of the eggs of several aquatic species of *Hemiptera*), and in Thailand certain species of wasps, bamboo caterpillars, crickets, and locusts are sold as delicacies in fine restaurants (DeFoliart 1999). Termite queens are served on special occasions in many African countries. In parts of Italy and Croatia cheese maggot is a delicacy, and in Japan *inago* (rice-field grasshoppers) and canned wasps are considered luxury foods (Tabassum-Abbassi et.al. 2016).

The belief that people only eat insects if they are on the brink of starvation is a misnomer. The Western attitude of insects as "disgusting" is a unique cross-cultural attitude (Looy et. al. 2014). Such an attitude has influenced traditional cultures to devalue and reject insect foods as their societies become more Westernized (Schiefenhövel and Blum 2007:166). However, scholars point to the importance of changing these Western attitudes; accepting insects as a food source would arguably assist with future food needs on a global level (Defoliart 1999; Lensvelt and Steenbekkers 2014; Looy et al. 2014).

My first encounter with edible insects in Lao PDR was in April of 2001. I went on an overnight hill-tribe trek into the Nam Ha National Protected Area[1] in the northern Luang Namtha province. On the first day, our guide packed a lunch from town and around noon we enjoyed it in the shade of a bamboo forest near some hillside fields in fallow. He offered us many Lao dishes, but the two I remember the most were cow brains and ant eggs. Both were seasoned with chili peppers, mint leaves, lime juice, and other aromatic herbs. At the time, mad cow disease was prevalent in Britain and Europe. Fearful about eating any beef products due to the international media hype, I decided to pass on trying cow brains. However, I did eat the ant eggs—small gray capsules that resembled a legume. In fact, I initially ate them thinking they were legumes, and I liked them. It wasn't until we began hiking again, when our guide spotted an ant nest in a tree, that he told me, "This is what you ate for lunch." Although a little shocked, I wasn't horrified because it wasn't the first time I'd eaten insects. The previous year I had eaten fried termites in Malawi, Africa, when I was a Peace Corps volunteer. At that time insects were a novel food to me, a food one bravely tried or dared others to eat. I didn't consider insects as a regular food source let alone a sustainable one. But in the 16 years since I ate ant eggs in Nam Ha, I have gained a whole new perspective on insects as food (entomophagy). I have since tasted many other insects, mostly in Southeast Asia but some in the U.S., imported from Thailand or Mexico. And for the past several years I have explored insects as a sustainable food option, inspired by the 2013 Food and Agricultural Organization (FAO) report "Edible Insects: Future Prospects for Food and Feed Security Sustainable Food Option".

In this article, I examine traditional sustainable practices in Northern Lao PDR vis-à-vis edible insects. Conversations about sustainability in post-industrial nations tend to circle around topics such as creating green neighborhoods and green buildings, conserving our water consumption, recycling the packaging of our food, and taking eco-friendly vacations. We talk about lowering individual carbon footprints while the international community talks about carbon sequestering and ways countries can earn carbon credits through the REDD+ program[2]. In the Lao language, there are no words for sustainable, sustainability or conservation; instead these concepts must be explained using numerous words, ideas, phrases, and hand gestures. In the Western world, the main precept of sustainability is "development that meets the needs of today without compromising the needs of future generations" (Parr 2009:1). In a subsistence-based system where people are reliant on the land, it is in their best interest to care for it for the sake of their own livelihoods as well as that of future generations. Despite the limitations of a lexicon that can make conversations about sustainability difficult, modern resource-conserving techniques often originate from or imitate traditional agricultural systems. Examples include planting many crops (polyculture) rather than depending on just one (monoculture), creating living windbreaks, and intercropping or growing different species among each other for ecological benefit. These traditional management techniques have been used for thousands of years to sustain yields and livelihoods, maintain soil fertility, and decrease erosion.

The goal of this article is to share the knowledge and aspects of traditional livelihoods that utilize natural resources efficiently, while showing the complexity of the whole system in the uplands of Lao PDR. The concepts of traditional and sustainable can go hand in hand, and perceptions of what sustainable practices look like on the ground can be broadened so that multiple stakeholders can recognize and value the complexity of the upland agroecosystems in Lao PDR. In other words, "the point of view is a perspective, a partial, subjective vision…. but it is at the same time a view, a perspective, taken from a point, from a determinate position in an objective social space" (Bourdieu 1987:2 cited by Nazarea 1999:9). Sustainable living patterns and options vary from culture to culture; this article sheds light on some sustainable traditional practices and the benefits of maintaining them. I hope that in illuminating the benefits of some traditional knowledge and practices, people will have the *choice* to continue practicing them in the future, instead of being pushed to change their practices in the name of development and economic progress

In this article I first discuss important background information pertinent to my argument that sustainable and traditional can go hand in hand. Traditional agriculture is described to demonstrate the complexity of upland shifting cultivation and the variety of products it contributes to local livelihoods. The upland agroecosystem is organic by default, which has great economic potential for crop production and insect collection. I briefly highlight current government land-use policies that undermine sustainable aspects of the upland system. Government encouragement to farm industrially, using chemical inputs and monocultures, decreases the availability and safety of insects as food. It also undermines the natural potential of the uplands since the steep terrain is not compatible with industrial monocultures. Next, I define Traditional Ecological Knowledge (TEK) and show how integral it is to upland livelihood systems, especially the maintenance of edible-insect activities. And I validate the need to maintain TEK now and for future generations. into the future. I also present data on insect availability and the prices I found in five markets across the region in December of 2016, revealing Lao PDR's economic potential and its unique position in regard to taking advantage of insect-eating traditions. I cite international research about the low environmental costs of raising or collecting edible insects, their rich nutritional content, and other benefits and issues of insects as food sources. Finally, I argue that traditional insect knowledge and collection has the potential to be an economic boon, benefiting farming households in the uplands by maintaining traditional agroecosystems while at the same time preserving traditional lifestyles with dignity. If government perspectives of sustainability are broadened and policies are created for the maintenance and sustainable management of traditional agroecosystems, the economic potential of edible insect markets in Lao PDR may greatly contribute to the overall income of the nation.

Background and Setting

Research was gathered on two different fieldwork trips. Market surveys of edible insects in Lao PDR, Thailand, and Myanmar were conducted in December 2016. And while conducting research for my Ph.D. dissertation, I lived in a rural agrarian village in the northern district of Vieng Kham, Lao PDR, from June 2009 to May 2010. Methods used included participant observation, structured interviews, unstructured interviews, pile sorting, ranking, participatory photography, and focus-group discussions. At the time I was working with the Center for International Forestry Research's Landscape Mosaics Project in six villages. As a collective, the six villages were known as the Muang Muay *kumban,* named after the largest village of Muang Muay (where I resided), which then was comprised of 168 households or 956 individuals. Comparatively, the smallest village in the *kumban* had 39 households. The most populous ethnic group across the villages was Khmu (ethnolinguistically categorized as Mon-Khmer speakers of the Austro-Asiatic super stock). One village, *Bouammi*, was predominantly composed of White Tai people (ethnolinguistically considered part of the Tai-Kadai language family). Muang Muay village was the only village of mixed ethnicity, with 138 Khmu households and 30 Tai/Lao[3] households, at the time of research.

Description of Current Agroecosystem

There are sustainable aspects to the current upland shifting cultivation system used by most villagers in Northern Laos. Land is slashed in January or February and left to dry for a month. Slash is burned in February or March in preparation for the rainy monsoon season, which generally runs from April through October. The ash acts as a natural fertilizer. On sloping terrain, land is not tilled or bunded because the soil is not fertile enough for the labor investment required for such land preparation. Once the rains start—the main source of irrigation—people begin to plant their rice seeds and other plants in rows using a dibble stick (a sharpened bamboo pole). Men often make the holes while women follow behind placing the seeds in the hole[4] and burying them.

Once the rains start, people go to their fields daily to weed, typically with a hoe, to scrape weeds away from the rice seedlings and plants. Corn, cucumbers, peanuts, pumpkins, and Job's tears are planted in a similar manner. Rice is harvested anywhere from 90 to 120 days after it's planted, depending on the variety. During harvest people cut the panicles off the stalks, pile them, and collect the piles into bags at the end of the day. People commonly pile the bags in a central location in the field and thresh the panicles in-situ, reducing the weight of their final load. Many fields are more than a kilometer away from people's homes. Grains are stored in bamboo-constructed granaries that generally sit under stilted houses. Rice is taken out of the granary as needed, milled or pounded, winnowed, and then cooked. The chaff is fed to ducks, chickens, and other domestic livestock. Large livestock are tethered in fields to eat the remaining rice straw and emergent grasses; for days buffaloes and cows will feed in the fields, depositing manure (which helps with soil fertility). Naturally occurring species such as *Chromolaena odorata* also put nutrients back into the soil (Roder et al. 2006). The complexity of the system involves a variety of livelihood activities that enables some rural households to remain mostly self-reliant. Self-reliance, or the ability to *sustain* oneself, is an important livelihood-security mechanism—one that saved many citizens during the Vietnam and Secret War Era of the 1960s and 70s.

The upland shifting cultivation system in Laos may be referred to as organic by default, or traditional agriculture. Defined by Bennet and Franzel (2013), traditional agriculture encompasses systems that evolved before synthetic agrochemicals and many (not all) use local ecological processes for enhancing productivity while conserving the natural resource base. Organic rice production is being promoted in the country due to the historical dearth of chemical inputs (Roder et. al. 2006). Bennet and Franzel argue that traditional agriculture "is becoming increasingly rare. Population pressure has curtailed long fallows in particular, leading to an accelerating rate of widespread soil degradation" (2013:195). Given Lao PDR's current government model of modern developmentalism, the country aspires to modernize in ways world powers are modeling, e.g. industrial agriculture. The transition from traditional systems to intensive industrially based systems in the lowlands is happening at a rapid rate. However, the uplands are much more difficult to industrialize due to steep terrain and a lack of infrastructure; thus, many households continue to practice traditional techniques which are organic by default. Organic by default cropping systems have the potential to earn farmers high prices on the international market. In addition to economic benefits there are environmental, social, and health benefits in maintaining this traditional system.[5] There is potential to convert much of the uplands farmland to certified, organic world standards, which will fetch superior prices on the international market.

Although shifting cultivation is often blamed as the culprit of deforestation in many tropical nations, it is a sustainable system in areas with low population density (Delang 2007; Tayanin 2007; Yokoyama in print). People who are reliant on this system of agriculture utilize the land and the products/resources from it in a much more efficient way than industrial agriculture utilizes natural resources. A shifting cultivation system is reliant on human energy and minimal fossil fuels, if any at all. Rain is the irrigation, and sometimes gravity-fed irrigation is used; there are no pumps used to transport water, e.g., no fossil fuels or electricity. Most farming households rarely use manufactured fertilizers, pesticides, or insecticides. Comparatively, 2015 data from the Iowa Extension Service suggests that inorganic fertilizers account for 40 percent of an American farmer's input costs (The Fertilizer Institute 2017). Fossil fuels are a basic building block of inorganic fertilizers. A brief case study of inorganic nitrogen and fossil fuels exemplifies the difference of inputs in the two systems. It is estimated that the U.S. industrial agricultural system uses 1.4 to 1.8 liters of diesel fuel to create 1 kilogram of nitrogen fertilizer (Pfieffer 2004). From 2001–2002 nitrogen fertilizer use reached 12,009,300 kilograms in the U.S., which equates to approximately 15.3 billion liters of diesel fuel if calculated using the lower number of 1.4 liters of fuel per kilogram of nitrogen fertilizer (Pfieffer 2004). It is estimated that 400 gallons of oil is used to feed one person a year (Pfieffer 2004, based on 1994 data by Piemental and Giampetro). The bulk of the 400 gallons, or 31 percent, is used to manufacture inorganic fertilizer, while 19 percent goes toward operating machinery, 16 percent is used to transport crops, and 13 percent is used for irrigation. Comparing the single variable of energy use in the U.S.

industrial agricultural system to that of an upland shifting cultivation system in Lao PDR, the sustainability of the Lao system becomes much more evident simply by the lack of dependence on fossil fuels. Although upland soils are low in nitrogen, research shows that upland farmers generally do not apply it; even in areas of industrial agriculture, farmers apply less than 20 kilograms of nitrogen fertilizer per hectare (Roder et, al. 2006). This brief comparison only considers some aspects of fossil fuel consumption and one inorganic fertilizer. There are numerous other variables to be discussed, however, which are beyond the scope of this paper. The brief comparison presented demonstrates that minimal inputs and in-situ nutrient recycling are sustainable features of the Lao upland agroecosystem.

Government Policies, Traditional Ecological Knowledge, and Non-Timber Forest Products

In the late 1990s and into the 2000s the government of Laos (GOL) implemented the Land Use Planning Land Allocation system (LUPLA) to encourage farming households to participate in growing permanent crops and cash crops instead of using their traditional shifting cultivation methods. LUPLA[6] limited farmers' access to agricultural lands by allocating only three plots of land per household for agricultural activities.[7] This program greatly reduced traditional fallow periods (e.g. traditionally the Khmu had an 11-year system and the Hmong a 20-year system). With LUPLA, farmers could only allow the fields to lay fallow for two years. LUPLA has since been highly criticized after research demonstrated it created a "new" government-induced poverty (State Planning Committee 2001:79). The logic behind this program was that the state would gain more control of the forests and natural resources, manage them for national economic development, and put pressure on farmers, thus rendering shifting cultivation a nonviable livelihood option in the near future and eventually forcing many to abandon farming altogether and become day laborers.[8]

Although fallow periods dramatically declined after LUPLA, people still collect and utilize products that naturally grow on their fields. The recognition, collection, and processing of these products requires Traditional Environmental Knowledge (TEK), also referred to as Indigenous Knowledge (IK), local environmental knowledge, or ethnoecology (Hunn 1999). I use the acronym TEK referring to "cultural perceptions of nature, the environment, and natural processes" (Kabuye 1999). Within the agroecosystem explained herein, it is important to recognize the value of *all* products, not just domesticated crops. The value of TEK cannot be downplayed as it is this intimate knowledge of natural resources that has allowed humans to survive from time immemorial. In addition to foods, building materials and non-timber forest products (NTFPs) are collected, many of which contribute significantly to household incomes (discussed below).

TEK is vital to living off the land and knowing what natural resources are available locally. It is also vital in understanding the ecology of an area and the life cycles of organisms that are of value to humans to avoid overharvesting certain species. For example, the ability to identify wild foods such as mushrooms or insects requires a deep understanding of one's environment. As societies start to modernize, TEK declines as younger generations pursue occupations that don't require them to maintain an intimate knowledge of their natural resources. Almost two decades ago, Hunn (1999:27) suggested that TEK was in a vulnerable "use it or lose it" situation, stating that, "To preserve the full value of TEK, we must allow the members of traditional communities the opportunity to apply it to their daily lives, to maintain it, modify it, and pass it on to their descendants as still useful knowledge". TEK remains vulnerable, but it can benefit modern society in many ways such as the knowledge of wild insect collection, processing, and food preparation.

Fortunately, in the Muang Muay *kumban* and elsewhere throughout Northern Laos, I observed villagers maintaining a plethora of TEK. It is still common for people to collect an assortment of wild products including edible and medicinal leaves, bamboo shoots, rattan shoots, edible insects, wild fruits, and other plant parts for food and medicine (Roberts 2011). There is a need to tap into TEK to manage wild products and ecosystems in a sustainable manner. Given the high maintenance of TEK in Lao PDR, there is great potential for local people to assist with sustainable management practices of wild species including NTFPs and edible insects (Durst and Shono 2010; Johnson 2010; Yen 2012).

Villagers continually utilize their TEK to forage and process

NTFPs for household consumption and use, and to sell at the market. Foraging for insects requires an intimate understanding of each insect's life cycle, it requires TEK. For example, *dtho mae*[9] or bamboo caterpillars, are the larval stage of the moth *Omphisa fuscudentalis* of the Crambidae family of lepidoptera. The bodies of the caterpillars are white and three to four centimeters long. They have an annual life cycle; adults emerge in late July to early August and mate at night, then female moths lay 80–130 eggs near the bottom of bamboo clumps. In 12 days the eggs hatch and together bore a hole into the bamboo stem in one day. Next, they bore an exit hole for adult emergence. The larvae continue to bore holes between the internodes, feeding on the pulp. Inside the stem they are protected from predators such as birds and reptiles. After feeding for 45 to 60 days, in September they have reached larval maturation and congregate in the internode near the exit hole. They remain as larvae in this internode for nine months and start pupating in June (Singtripop et al. 1999). Research shows that the larvae weigh the most in the first months of congregation, but body fat starts to fluctuate as they sit in the internode and by March the protein content significantly decreases (ibid). To collect them at their largest and most nutritious stage requires harvesting them in September, October, and November. They complete their metamorphosis into adult moths that emerge again in July and August (Hanboonsong and Durst 2014:6; Yhoung-Aree and Viwatpanich 2005:437).

Collection occurs after the rainy season in the forests, generally in the mornings. One only needs a knife and some experience in locating the culms where the larvae are congregated. TEK shared by local people tells us that thinner culms and shorter internodes are the two main criteria for locating the caterpillars. Once located, bamboo culms are slashed and the caterpillars are gathered by hand and stored in a leaf or bamboo culm. One bamboo stem generally contains between 40 and 50 caterpillars, and 400 caterpillars constitutes approximately 1 kilogram (Hanboonsong and Durst 2014:6.) Bamboo clumps often grow on fields that have been fallow two years or more. In the Muang Muay *kumban* fresh bamboo caterpillars were sold in the village market only in October and November,[10] offering a rich supplement to the local diet (Image 1). Caterpillars sold for 35,000 to 37,000 kip (about $4.35) per kilogram. Although villagers sold caterpillars to each other, most were sold to a merchant coming from the town Vieng Kham, who sold them at a higher price to his next customers. Regardless, the price the villagers received for bamboo caterpillars was the highest per-kilogram NTFP price I witnessed.[11] This high market price indicates the cultural value of and desire for bamboo caterpillars. Online today, dehydrated bamboo caterpillars are priced at $5.80 for 10 grams, which means one kilogram sells for $580 (Thailand Unique 2017)!

One of the most valuable non-insect NTFPs in the Muang Muay *kumban* in 2010 was broom grass or *kheme* (*Thysanolaena maxima).* TEK played a role in how villagers propagated broom grass on their fallow fields. Many burned their fields after a crop harvest to increase the flower production of the naturally occurring broom-grass clumps. After the grass blooms, people collect, dry, and beat the seeds out. They then bundle the flower heads with a foot or more of stem attached to sell to the merchant from Vieng Kham. Truckloads of broom grass are sold from January through March. In 2010, broom grass was selling for 3,000 to 4,000 kip ($0.35 to $0.47)[12] per kilogram in the Muang Muay market. One person can reportedly harvest 10 to 15 kilograms of broom grass in a single trip and make two trips in a day (Lao-ntfpwiki, 2010). One individual could potentially make 120,000 kip ($14.10) for one day of collection and one day for drying and processing. This is a significant amount of money given that some villagers reported annual cash incomes as low as $59 in 2010 (Roberts 2011). In 2010 an elderly village woman exclaimed to me, "Every penny I have is from nature!" This discussion of TEK and NTFPs substantiates her comment.

The availability and collection of NTFPs depends on the season, plant succession, labor, and market demand. There are many more NTFPs collected from fallow fields and community forests as I have discussed elsewhere (Roberts forthcoming), however the point of briefly discussing NTFPs herein is threefold. First, it demonstrates that the land is used either for crops or to harvest wild species—the land is not useless when fallow—demonstrating resource-use efficiency, a sustainable feature of shifting cultivation. Second, people who rely on their natural resources for the bulk of their subsistence understand the natural cycles of the plants and animals intricately and often maintain a plethora of TEK. Third, with small population densities, low levels of deforestation, and limited habitat destruction, it is possible to maintain the succession of cultivated foods, wild foods and non-food plants on a single plot of land that contributes to a household's overall quality of life. If people have access to enough resources to harvest valuable NTFPs to sell and earn cash, then they are part of a cash economy. The Lao government wants traditional shifting cultivators to contribute to a cash economy. Traditional farmers in the uplands can contribute more products and cash when government policies allow them to maintain regenerative fallow periods. Furthermore, in times of cultivated food shortages—often caused by natural and unpredictable events such as pest infestation, a poor rainy season, or a decrease in household labor due to accidents—NTFPs and TEK are livelihood-security mechanisms. For example, people may collect more bamboo shoots, rattan shoots, mushrooms, and insects to replace the dearth of calories from unavailable cultivated foods such as rice and peanuts. They also have the option to sell NTFPs for cash to purchase food items.

Traditional Insect Practices in Lao PDR

Collecting insects for home consumption is a traditional practice in Lao PDR, where most people consume insects (Hanboonsong and Durst 2014). At least 50 edible insects are eaten over the course of a year in Lao PDR. The most preferred are weaver ant larvae and pupa; short-tailed crickets; house and common crickets; grasshoppers; and cicadas (Hanboonsong and Durst 2014:1).

Agronomists predict that food resources need to increase by 60 percent to meet global food requirements by 2050 (Hanboonsong and Durst 2014). Due to insects' high nutritional value (rich in fats, amino acids, and protein) and low environmental cultivation demands, as well as the growing global population, the United Nations suggests that insects are an underutilized food resource with the potential to greatly contribute to diets around the world. "The percentage of the population in Lao PDR that consumes insectsis one of the highest in the world" (Konuma 2014[13]). Because entomophagy is traditionally accepted here, the FAO of the United Nations targeted Lao PDR as a place to build upon tradition and increase the awareness of the benefits of edible insects. A large part of this effort was done through the project "Sustainable Insect and Harvesting for Better Nutrition, Improved Food Security and Household Income Generation in Lao PDR," implemented from 2010–2013.

Economics of Edible Insects

Research suggests that NTFPs including edible insects provide 50 percent of the cash income of many households in rural areas, where 80 percent of the population in Lao PDR resides (Hanboonsong and Durst 2014). As previously discussed, bamboo caterpillars fetch high prices for villagers in the Muang Muay *kumban*. Other insects sold in the Muang Muay market from 2009–2010 included rhinoceros beetles (*Xylotrupes gideon*) and a variety of other beetle species (Coleoptera) that sold for $0.11 per five insects. In this case study, bamboo caterpillars resulted in a higher profit for villagers, but other insects also have the potential to make villagers good money. In the village of Dong Makkhai, Lao PDR, 21 species of insects are collected and sold at the local market, accounting for 23 percent of the combined household income of the village (van Huis et al. 2013:46). In Thailand in 1992 one kilogram of grasshoppers sold for $2.80, a small farmer could earn up to $120 per half-acre of collected grasshoppers or twice as much as s/he could earn selling corn grown on that same half-acre (Anon 1992 cited in DeFoliart 2005:131). In 1999 the grasshopper trade averaged about $6 million in Thailand, while ant sales in China amounted to approximately $100 million (DeFoliart 1999:33). One entrepreneur in Thailand estimated that his insect packaging business saw more than one million kilograms of crickets per year in the early 2000s and he purchased them for between 80–130 baht[14] per kilogram (Yhoung-Aree and Viwatpanich 2005). Ten middlemen were involved in this business, many of whom purchased insects from collectors along the Lao, Cambodian, and Myanmar borders. In 2013 Hoonbonsong reported about a Thai entrepreneur who reportedly sold 20,000 kilograms of bamboo caterpillars per year, of which 10 -20 percent come from Lao and Myanmar traders. He purchased them for 250 baht ($8.33) per kilogram and then froze and cooked them. Frozen packs were sold for 365 baht ($12.16) per kilogram and 1,000 kilograms were generally sold each month. Cooked and packaged bamboo caterpillars were sold at 130 baht ($4.33) per 100 grams (Hoonbonsong et. al. 2013). In 2008 Sribandit et.al found that the queen brood of the Asian weaver ant sold for twice as much as beef (per kilogram) and almost three times the price of chicken in Thailand. In Japan in 2013 wasp nests sold for $100 per kilogram (van huis et al. 2013:139). Edible insects have a market demand and therefore assist people in increasing their income. Raising or collecting edible insects has the potential to assist low income households in the Lao PDR and across Southeast Asia generate income.

Preliminary Market Surveys

In December of 2016 I conducted preliminary market surveys on edible insects in five markets in three Southeast Asian countries (Lao PDR, Thailand, and Myanmar). The results of the surveys are compiled in Table 1.

Table 1
Market Surveys of Edible Insects in the Region in December 2016

Location	*Insect*	*Price*
MyanmarYangon Night Market	Palm weevil pupa/grub *Rhynchophorus spp.*	4,000 kyat ($2.97) for one pupa (alive when purchased; fried after purchased)
MyanmarYangon Day Market	Mole crickets *Gryllus bimaculatus*	1,500 kyat ($1.11) for 10 uncooked insects)
	Small crickets *Acheta domestica*	1,500 kyat ($1.11) for 20 uncooked insects)
Myanmar (Rakhine State)Mruak U Morning Market, day one (Dec. 12, 2016)	Small water insect of the *Cybister spp.*, Coleoptera order, Dytiscidae family (Hendrich and Brancucci 2013)	2,000 kyat ($1.49) for 100 uncooked insects
Myanmar (Rakhine State)Mruak U Morning Market, day two (Image 2)	Same as above: *Cybister spp.* Large water bug *Lethocerus spp.*, Belostomatidae family (Image 3) uncooked insects	2,000 kyat ($1.49) for 100 uncooked insects 2,000 kyat ($1.49) for 20
Lao PDRLuang Prabang Morning Market (Image 5)	Beetle (Coleoptera*)* possibly a *Hydrophilus spp.* (unidentified) Image 4)	10,000 kip ($1.25) for a plate of boiled insects (aprox.60-70 insects)
	Crickets *Acheta domestica*	10,000 kip ($1.25) for a plate of fried and seasoned insects (aprox. 70-80 insects) 50,000 kip ($6) for 1 kilogram (uncooked)
	Silk moth pupa *Bombyx mori*	10,000 kip ($1.25) for a plate of fried and seasoned insects (aprox.50-60 insects)
ThailandBangkok's Suvarnabhumi District Night Market	Small crickets *Acheta domestica* Mole crickets *Gryllus bimaculatus* Silk moth pupa *Bombyx mori*(Image 6)	20 baht ($0.66) per plate of fried and seasoned insects (aprox. 70-80 small crickets; 50 mole crickets and 50 silk moth pupa)

Table and surveys conducted by author from December 7–23, 2016.

Brief Discussion of Markets from Table 1

Observations and conversations with local people in the markets revealed several cultural insights. Palm weevil grubs (*Rhynchophorus spp.*) in the night market in Yangon were mostly eaten by men drinking alcoholic beverages. The price was surprisingly high—$2.97 for one insect—suggesting that vendors may earn high profits on these grubs and that they are not affordable to households of all socioeconomic strata. A Burmese friend of ours liked to eat the grubs raw, like sushi, saying he found them buttery and creamy. His family belonged to the upper strata of society; he was a restaurant-bar owner in Yangon and previously lived in the U.S. for 13 years, working as a chef. In contrast, at the large village market in Mruak U, insects were sold at a more affordable price although there were only two species available: a small and large water insect (*Cybister spp.* and *Lethocerus spp.*, respectively). (Aquatic insects are available year-round while terrestrial insects are seasonal.) One female vendor who was selling both species had sold out of the *Lethocerus spp.* by 8:30 a.m. the first morning. The second morning we arrived earlier to document the large water insect; it appeared to be scarcer, in higher demand, and sold for a higher price than the *Cybister spp*. We purchased some small water insects and had them fried up at a local restaurant. Our Rakhine friend said most people eat them as a snack when they are drinking beer or whiskey due to their strong flavor (noticeable to my palate). Finally, one vendor in Yangon day market was not busy and he said some days were busier than others. He purchased the two species of crickets he was selling at a wholesale market, indicating they were farm-raised. Our Burmese friend, who accompanied us to the market, said he had only tried a cricket once, believing it made him sick to his stomach because insects are "dirty." He likely won't ever try one again, he said. Our friend was a young adult of high socioeconomic status who spent his four years of undergraduate school in the U.S. His reaction to edible insects mirrored Western attitudes of disgust and repulsion. Also of note: Conversations with three local people who accompanied me to each of the markets in Myanmar suggest that insects are most often eaten as snacks when drinking alcoholic beverages, though, it appears that Western influence is diminishing the acceptance of this practice.

The Luang Prabang market had the highest number of insect vendors (four female merchants) compared to other markets, demonstrating a high market demand and the cultural saliency of entomophagy in Lao PDR. Cultural saliency of edible insects in Thailand was equal to that in Lao PDR. When I asked our Bangkok hotel staff if the nearby market sold insects they emphatically replied, "Yes, they always have insects there." Thus, the one female vendor frying and selling the three species of insects at the Suvarnabhumi market had a well patronized stand, selling a plate at least every 90 seconds. Her prices were the lowest out of all the countries, which was unexpected since Thailand has the highest GDP per capita of the three countries. A government report of the Phu Wiang watershed in Thailand found that 93 percent of households gathered 25 species of insects for consumption and 9.3 percent of households gathered eight species to sell (DeFoliart 1999:33). To further substantiate the cultural salience and widespread acceptance of entomophagy in Lao PDR and Thailand, a booklet published by the Ministry of Public Health in Thailand in 1987, "Manual for Using Food Which Provides High Protein and Fat in Rural Areas," includes six edible insect species, and a book titled *What's in the Market? A Visitor's Guide to Lao Tastes, Culture, and Daily Life*, published by Big Brother Mouse[1] in 2010 includes five edible insects and honeycomb as an insect-derived dessert. Surveys in Lao PDR found that mothers start to feed their children "softer" insects (bamboo caterpillars, bee larvae, and ant eggs) at the age of 10 months (Hangboonsong and Durst 2014:27). Preliminary market surveys coincide with others' findings, suggesting that insects are common fare in Lao PDR and Thailand but are becoming a more novel food in Myanmar, reticence of which may be due to that country's British colonial history[2] and modern Western influences (Yen 2009 discusses the Western phobia of edible insects; also refer to Looy et.al 2014).

Environmental Benefits of Insects as Food

Raising insects results in fewer greenhouse gas emissions, lower energy inputs, less water, and less land than raising conventional protein sources. It is logistically difficult to calculate inputs of wild insects, so research conducted on the environmental footprint of insects has occurred in controlled settings. Wageningen University in the Netherlands, one of the leading research institutions concerning entomophagy, conducted research on light-industrial-rearing facilities and found that the global warming potential (the CO_2 equivalent) of mealworm production was lower than the production of milk, pork, chicken, or beef (per kilogram of edible protein). In a case study by Oonincx and de Boer 2012, mealworms raised in the facility were fed carrots and mixed grains grown off-site; however, organic side streams[3] can also be used as insect feed, greatly reducing the already low environmental impact of insect-rearing. For example, 18 square meters (m^2) of land are needed to raise one kilogram of edible mealworm protein when raised on carrots and mixed grains; however, only 0.04 m^2 of land is needed when raised on organic side streams. In comparison, 142-254 m^2 of land are needed to raise one kilogram of edible protein from beef, and 95–237 m^2 of land are needed for pork (Oonincx and de Boer 2012; Chapagain and Hoekstra 2003 cited in Tabassum-Abbasi et. al. 2016). Most of the environmental footprint of raising mealworms was attributed to the cultivation of carrots and mixed grains, which accounted for 99.5 percent of the land use, 44 percent of energy use, and 56 percent of the global-warming potential. Gas and electricity (for transportation and within the facility) accounted for 43 percent of global-warming potential and 56 percent of energy use (Oonincx and de Boer 2012). Although agricultural products account for most of the environmental footprint of raising mealworms, it is still significantly less than raising beef, pork, chicken, or making milk. In a controlled setting, the most environmentally friendly and, therefore, sustainable option is to raise insects on organic side streams (Ramos-Elorduy et. al. 2002; Nadeau et.al. 2015). Insects raised in a non-controlled setting (e.g. wild-grown) require no agricultural inputs[4] and contribute ecosystem services (pollination, decomposition, etc.). In Lao PDR edible insects are collected in fallow fields, forests, along stream edges, and elsewhere in the local environment; therefore, as a food resource they have minimal global-warming potential.

Low Water Requirements

Growing insects uses significantly less water than raising livestock and other industrial agricultural crops. The world uses approximately 92 percent of the global freshwater supply for agricultural pursuits (Hoekstra and Mekonen 2012). Raising insects requires much less water than raising conventional forms of animal protein. For example, it is estimated that 1 kilogram of beef in live weight requires 9,700 liters of water whereas one 1 kilogram of mealworms reared on organic side streams requires 2.5 liters of water (Nadeau et al. 2015:203). When considering land, energy, and water use, wild insects are the most environmentally friendly food option. Currently, wild collection is a sustainable practice in Lao PDR, but overharvesting could become an issue and management schemes may need to be implemented to maintain the sustainability of wild collection.

Nutritional Content

Many edible insects provide satisfactory amounts of energy and protein, meet amino-acid requirements for humans, are high in monounsaturated and/or polyunsaturated fatty acids and are rich in micronutrients such as copper, iron, magnesium, manganese, phosphorous, selenium, and zinc, as well as riboflavin, pantothenic acid, biotin and, in some cases, folic acid (van Huis et.al. 2013; Rumpold and Schlüter 2013). Nutrient profiles of many insects rival or surpass those of conventional livestock. For example, out of 249 edible insects from nine orders that have been analyzed for their nutrient content, 83 percent have a protein content that is greater than 40 percent of their body weight, while 43 percent have a protein content greater than 60 percent of their body weight. The majority (72 percent) are rich in lipid content, with a body composition that is more than 40 percent lipids[5] (Tabassum-Abbasi et. al. 2016:1760). Insect-based proteins are high quality, "containing all indispensable amino acids in favorable proportions," and they're more easily digestible than macrolivestock (Tabassum-Abbasi et. al. 2016:1760). For example, 82–90 percent of proteins in grasshoppers and termites are easily digestible—especially after removing the exoskeleton—and low in cholesterol (Tabassum-Abbasi et. al. 2016:1760).

Promoted as Minilivestock

Since insect-rearing has a much lower environmental footprint and better food-conversion efficiency than other livestock (e.g. protein sources) they are promoted as minilivestock, with the potential to help solve the world's food deficit. Nadeau et. al. (2015) hypothesize that the world's food deficit of 67.7 billion kilocalories per day could be erased with the production of 30.2 million kilograms of mealworms per day. Using organic side streams as feed, only 15,586 hectares of land is needed for minilivestock-rearing facilities. This is only 0.0003 percent of the almost five billion hectares currently being used for agriculture. Nadeau et. al. (2015) theoretically propose edible insects as a solution to world food shortages. Although they do not consider societal complexities such as political ecology, lack of access, and unequal distribution, their figures raise hope for future food challenges. Raising insects as minilivestock is being promoted in cultures where entomophagy is culturally salient, and the Lao PDR is one of these places. Citizens of Lao PDR have traditionally collected insects in the wild, but insect farming is a relatively new concept, supported by the FAO and the National University of Lao PDR (NUoL) with the creation of the Edible Insect Demonstration Unit at the university in December of 2010. Several educational activities such as hands-on trainings, printed manuals, and video CD's were used to disseminate insect-farming knowledge to local farmers and extension agents. By 2013, there were 27 cricket farmers producing 19,000 kilograms of house crickets and mole crickets. The farming operations are small scale; rough estimates suggest that an annual net income of $1,250 can be made from a 60 m² breeding area containing 61 concrete enclosures. Start-up investment for such an operation is low—at about $760—as are daily labor requirements—about one hour per day for feeding and one labor day to transfer) eggs (from the adult enclosure to a new enclosure) every 45 to 60 days (van huis et al. 2013:25).

Other Benefits and Concerns

Insect collection and consumption has controlled insect infestations in many countries. For example, insecticides were unsuccessful in curbing the 1993–1994 locust (*Locusta migratoria*) outbreak in the Philippines, which resulted in farmers collecting, selling, and eating the locusts (DeFoliart 2005). A similar "foe into food" situation occurred in Thailand in the late 1980s with grasshoppers, which became a source of major income for farmers and which caused many to eliminate the use of chemicals for fear of people getting sick from consuming chemical residues found on insects gathered in agricultural fields (ibid). Farmers reaped economic benefits by not purchasing chemicals and by selling the grasshoppers. A similar situation occurred in South Korea, creating a boom in organic farming in the district of Chahwang Myun due to the collection of edible rice-field grasshoppers (*Oxya velox*) (ibid). The organic-by-default characteristic of upland agroecosystems in Lao PDR can be promoted beneficially to raise and collect clean[6] insects. Food quality and safety are concerns that need to be addressed. Although insects do not carry the diseases that many conventional sources of protein do (e.g., trichinosis or salmonella from contaminated meat or dairy products, etc.), food quality and safety regulations are still necessary (van Huis et al. 2013; Hanboonsong and Durst 2014). Most insects are cooked before being eaten, and research has found that boiling kills more bacteria than frying (Hanboonsong and Durst 2014:29-30). However, precooked insects purchased in markets have many other potential contaminants, just like other street foods (e.g., sitting in the hot sun for hours, etc.).

Deforestation, habitat loss, and pollution have greatly reduced the availability of some insect species in the wild. Minilivestock farms have been promoted for several decades in Thailand. In 2011 there were 20,000 small- to- mid-scale cricket farms in northeast Thailand raising about 7,500 tons of crickets, and in southern Thailand palm-weevil farming produced 43 tons, worth about 1,920,000 Thai Baht or approximately $60,924 (Hanboonsong et. al. 2013). Unfortunately, as with many natural commodities, as demand goes up, wild supplies are diminished or stressed; therefore, it's important to utilize local TEK to sustainably manage collection practices. Lessons from around the world show that the rise in the commercialization of edible insects has led to inexperienced collectors resorting to unsustainable harvesting practices (Ramos Elorduy 2006). More research needs to be conducted on insect ecology and sustainable collection. We must not forget that insects provide essential ecosystem services that contribute to human survival, such as pollination, decomposition, pest control and wildfire protection (van Huis et al 2013:45). While research continues to be conducted on sustainable management of wild insect populations, small-scale farms are currently a viable and sustainable option. Three small scale insect farmers in Vientiane

Prefecture, Lao PDR, have self-innovated insect-raising modalities; cultural knowledge from growing up in an entomophagous society and information from Thai cricket farmers/media helped inform their innovations (Hanboonsong and Durst 2014). More innovations will likely occur if insect farms in Lao PDR continue to be promoted. The economy of Laos can greatly benefit from the intimate knowledge (TEK) that Lao citizens hold from growing up in an entomophagous society.

Using insects to decompose waste or organic side streams and then feeding them to livestock has been successful in trial studies. For example, research on black soldier flies *(Hermetia illucens)* has shown that larvae decompose 50 percent of the mass of chicken manure and they are a high-protein feed for chicks, pigs, and fish—a solution where everyone benefits (Sheppard 1992; Tabassum-Abbasi 2016). Furthermore, maintaining edible insects as a viable food option in turn maintains TEK because it highlights the usefulness of local indigenous knowledge about natural resources, yet another win-win situation.

Conclusion

In this article, I discuss several traditional activities of villagers living in the uplands of Northern Lao PDR that are sustainable. Their overall livelihood system integrates many aspects of the natural world, which they utilize as efficiently as possible based on their observations of natural cycles. They utilize their traditional environmental knowledge (TEK) to collect wild foods when their fields are not cultivated with domestic crops. In so doing they increase their household income and livelihood resources. Insects are one of the non-timber forest products collected on a seasonal basis. Insect consumption greatly contributes to Lao residents' diets, aiding in nutritional content and especially in providing proteins, fats, and amino acids. Market surveys demonstrate that edible insects in Southeast Asia contribute greatly to household economies. Keeping the cultural saliency of insects alive in the region will continue to create benefits for local people by way of promoting insect farms and minilivestock production that potentially can be sold across the world, as exemplified by Unique Thailand's website. There is a need for Westerners to accept insects as food so insects can contribute to the world food deficit in an environmentally friendly way. The Food and Agricultural Organization of the United Nations and Wageningen University are promoting insect proteins. The world needs to recognize the multiple benefits of entomophagy, taking examples from traditional cultures such as those in the Lao PDR in the raising, collection, processing, and preparation of insects as foods. There is a need to recognize that the shifting cultivation system in the uplands of Lao PDR requires an intimate understanding of natural cycles and, when practiced with traditional fallow periods, it is sustainable. Government agendas such as LUPLA and perceptions of development for the economic future of the country have greatly undermined the sustainability of traditional agroecosystems. While some villages are faring better than others, the government and other stakeholder groups need to rethink their points of view of traditional shifting cultivation in the uplands, to recognize the value of *all* products yielded from this complex system. Products that are not only material but cultural, such as local traditional environmental knowledge, which has insights to offer toward the sustainable collection and raising of edible insects into the future. According to the United Nations, eco-agricultural approaches are becoming a priority (Giovannucci et al. 2012); traditional or organic-by-default practices in Lao PDR have much to offer, especially when coupled with responsible insect collection. These two aspects of traditional livelihoods in northern Lao PDR have the potential to contribute significantly to the national economy. Instead of looking for "new" development projects, it is in the best interests of the Lao government and citizens to put more research into what they already have and know. Traditions can be maintained, TEK can survive, and shifting cultivators can contribute more substantially to the national economy. Instead of replacing tradition with modern development, the two can mutually benefit and coexist if perceptions of sustainability and development are broadened.

Note

1 At the time it was a national biodiversity conservation area.

2 Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, part of the United Nations' framework convention on climate change. Visit http://redd.unfccc.int/ for more information.

3 Lao and tribal Tai people (not to be confused with Thai people, who are citizens of Thailand) are ethnolinguistically referred to as Tai-Kadai. In Lao PDR they are categorized together as *Lao Loum*, or people of the lowlands. There is a political benefit in referring to yourself ethnically as Lao, the group the country is named after. In some cases, people with White Tai or Red Tai ancestry will just refer to themselves as Lao. Ethnic labels and identities are seldom easy to define, partly due to their fluidity across time and space.

4 Agricultural extension agents in Luang Prabang province have attempted to get women to count how many seeds they put in each hole, suggesting that three seeds are enough. However, women I interviewed laughed at this notion, stating that the extension agents have time to count seeds because they're getting paid but for the women to count seeds was a highly impractical suggestion, see Roberts 2015.

5 There are thousands of articles and a plethora of other information available regarding the benefits of organic farming. A good place to start is the Rodale Institute's website: https://rodaleinstitute.org.

6 Later shortened to Land Forest Allocation (LFA); however, for consistency I will use LUPLA.

7 Households with tree plantations were allocated more than three plots of land since trees are considered a permanent cash crop within the LUPLA scheme.

8 See Baird and Barney 2017 for consequences of modern development on traditional livelihood systems and Singh 2012 for an in-depth discussion about the legitimation of power over natural resources in Lao PDR.

9 The Lao word for bamboo caterpillar, also transliterated as *to mir.* Variations occur in transliterations from Lao to English since there is no standardization.

10 Other research suggests that in Xieng Khouang province bamboo caterpillars are collected from October to January (Hanboonsong and Durst 2014).

11 Bush meat was much higher but infrequently caught and usually sold within the village, not to the merchant.

12 Where possible I have converted the local currency into U.S. dollar equivalents; the $, symbol indicates U.S. dollars.

13 Hiroyuki Konuma the FAO Assistant Director General and Regional Representative wrote this sentence in the Foreword to the FAO Report "Edible Insects in Lao PDR: Building on Tradition to Enhance Food Security" 2014. Unfortunately, he did not specify the percentage. It is known that at least 80% of the population of Laos lives in rural areas and collects Non-timber Forest Products a general category that included edible insects. One can deduce that at a minimum 80% of the population eats edible insects, however, many urban dwellers also eat insects, thus the percentage is likely much higher such as 90-95% of the population. I arrive at such a figure through experience and deductive reasoning, no reference I have viewed includes an exact percentage.

14 I have not converted this figure to U.S. dollars because the baht conversion rate in 2017 differs from the conversion rate when this research was conducted in the early 2000s.

15 One of the main publishing houses in the country located in Luang Prabang town. All books must be approved by the Lao government before publication (Personal communication 2010).

16 Sutton 1988 suggests this was the case in the Americas with the Great Basin Native American peoples, who began to suppress their insect-eating traditions due to the shameful judgements of colonialists (e.g. insects were foods of poor savages); apparently, edible gastropods (snails) from Europe were perceived differently, perhaps due to their expensive price tag?

17 Bio-waste from forestry, agriculture, and household processes, including manure, pig slurry, and compost, etc.

18 Although some insects may eat agricultural crops, I am referring to wild insects, for which crops are not intentionally planted.

19 It is important to note that nutritional value varies depending on the insect, their metamorphic stage when collected, the insect's habitat, and diet. For example, grasshoppers in Nigeria that were fed with bran (which contains high levels of essential fatty acids) have almost double the protein content of those fed on maize (van Huis et. al. 2013:70). Preparation also affects nutritional value; for example, is the insect fried, dried, boiled, baked, steamed, or frozen? And how do these preparation methods affect the nutrients of the insects? The FAO is attempting to standardize how nutritional values are measured. To include nutritional values on the International Network of Food Data Systems (INFOODS) database, insects must be measured as a 100-gram edible portion on a fresh-weight basis.

20 Free of chemical residues

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Image 1. Bamboo worms for sale in the Muang Muay Market, Viang Kham District, Lao PDR, October 2009. (Photo by author.)

Image 2. Insect vendors, Mruak U Morning Market, Rakhine State, Myanmar, December 11, 2016. (Photo by author.)

Image 3. Large water bug *Lethocerus spp*. Mruak U Morning Market, Rakhine State, Myanmar, December 11, 2016. (Photo by author.)

Image 4. Unidentified edible insect (possibly *Hydrophilus spp.)* in Luang Prabang, Lao PDR, Morning Market, December 20, 2016. (Photo by author.)(do you need to turn this photo? it looks sideways as is)

Image 5. Fried crickets and silk moth pupa for sale in the Morning Market Luang Prabang, Laos, December 20, 2016. Cooked over charcoal while you wait. (Photo by author)

Image 6. Insect vendor's deep-frying equipment in Suvarnabhumi Night Market, Bangkok, Thailand, December 23, 2016. This insect vendor cooked the insects in the largest batches and had the largest supply of insects. (Photo by Author.)

Image 7. The same vendor also displayed the insects alive, in a case. No other vendor showed them alive. (Photo by author.)

Image 8. The Thai vendor's cooked silk moth pupa on display for customers. (Photo by author.)