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The importance of weaver ant (*Oecophylla smaragdina* Fabricius) harvest to a local community in Northeastern Thailand

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Abstract. Ants of the species *Oecophylla smaragdina* are a valued resource in some Southeast Asian countries since they are edible. In Thailand they are an expensive delicacy collected in high numbers from natural habitats. In this study we interviewed 25 ant collectors in Nakhon Ratchasima Province to elucidate the extent of ant collection and its socioeconomic impact. On average more than 3 persons per village collected the ants, each collecting on average 219 (± 107.5) kg of ants per year. This yield led to a daily income of 411 THB (12.1 US$) per working day during the 4-5 month ant harvesting season, corresponding to approximately 1.5 - 2.6 times the minimum wage (162 THB day^{-1}) in the province. On average, the yearly income from ants constituted 30 % of the total household income among the ant collectors and additionally supplied their families with an animal food source. The major issues considered problematic by ant collectors were the increasing number of people collecting ants and high travel distances to ant sites. Increased harvesting pressure may put the natural ant populations at risk. We discuss ant farming as a potential solution to these problems.

Keywords: insects as food, ethnoentomology, entomophagy, Nakhon Ratchasima, ant farming, socioeconomy

INTRODUCTION

The weaver ants belonging to the genus *Oecophylla* consist of two extant species – *O. smaragdina* which is distributed throughout tropical Asia, Australasia and some Pacific islands and *O. longinoda* distributed throughout tropical Africa (Lokkers 1986). The species share similar biological and ecological characteristics. They are both polydomous canopy ants that build leaf nests on their host trees. Nests are constructed by drawing together leaves and fixing them with silk produced from their larvae (Cole & Jones 1948; Offenberg *et al*. 2006). The nests are easily visible and scattered throughout the canopy territory of the ants which can cover up to 1500 m^2 for a single large colony (Hölldobler 1983). The ants use a wide range of host trees and prefer sunny habitats. Therefore they are usually abundant in disturbed habitats with trees or bushes. Weaver ants are aggressive and will prey on most arthropods entering their territory and additionally scavenge on a wide range of organisms including vertebrates (Dejean 1991; Wojtusiak *et al*. 1995). Due to their predatory habit *Oecophylla* ants are recognised as biological control agents in tropical tree crops as they are able to protect a variety of crops against many different insect pests (Van Mele 2008; Way & Khoo 1992). In this way they are utilised indirectly as an alternative to chemical insecticides. It is less well known that the ants can be utilised directly also, as a commercial product. There exist at least three different markets for the use of these ants in Southeast Asia: (i) in Chinese and Indian traditional medicines (Chen & Alue 1994; Oudhia 2002), (ii) as a valued feed for song birds in Indo-

nesia (César 2004), and (iii) as a prized human delicacy in Thailand and other Asian countries (Bristowe 1932). In Chhattisgarh, India, traditional healers believe that regular intake of *O. smaragdina* will prevent rheumatism – a view shared by practitioners of traditional Chinese medicine (Chen & Alue 1994; Oudhia 2002). The Indian healers also prepare oils in which they dip collected ants. After 40 days oils are used externally to cure rheumatism, gout, ringworm or other skin diseases, or else as an aphrodisiac (Oudhia 2002). In Java there is great enthusiasm for keeping captive songbirds. According to bird lovers the larvae and pupae of *O. smaragdina* provide essential protein and vitamins to their birds and so will improve the bird's performance. For use as a bird food they are willing to pay up to US$1.4 per kg of ant brood. Lower-quality ant brood is used to feed chickens where it is believed to accelerate feather growth and flesh production (César 2004). The tradition of including *Oecophylla* ants in food and/or traditional medicine has been reported from various cultures in Thailand, India, Myanmar, Borneo, Philippines, Papua New Guinea, Australia and Congo (De Foliart 2008 and references therein). Especially in Thailand *O. smaragdina* is considered a delicacy and has been eaten by humans for centuries. Imagos as well as brood are used in a variety of Thai dishes and are easily obtained on many local markets throughout the country during the ant harvest season. Larvae and pupae are preferred over imagos and the queen caste preferred over the worker castes and males. The season in which *O. smaragdina* produce new queens therefore defines the ant harvest season. The ants are used as ingredients in soups, salads and fried dishes and sometimes eaten raw together with spices as a snack. The tradition of eating ants is most prominent among the Isaan people of Northeast Thailand and the people in Northern Thailand but has spread to other parts of the country with the migration of people from these cultures. A growing interest in the eating of ants has led to higher demand throughout Thailand with increasing prices as a result. Thus, the collection of ants is becoming more profitable and the harvest pressure on local *O. smaragdina* populations may increase accordingly, potentially leading to an unsustainable overexploitation of these ants in natural habitats.

The purpose of the present paper is to assess the socio-economic significance of ant harvesting and thereby evaluate the potential future pressure on this resource. We seek to identify factors that limit the trade, and conduct a preliminary assessment of the need for alternatives to the harvest of naturally occurring populations in order to prevent future over-harvesting of ants. In this context we discuss the development of ant farming as a way to prevent the unsustainable utilisation of ants as a food resource. Thailand is one of the countries where the utilisation of ants as a natural food resource is most prominent and organised, with the harvest of *O. smaragdina* in Northeastern Thailand particularly developed. The harvest of this ant in a province in Northeastern Thailand was therefore selected for the study.

METHODOLOGY

In 2005 a survey was conducted to document and elucidate the extent of *O. smaragdina* harvesting in Northeastern Thailand and its contribution to local livelihoods. Seven villages located in two districts (Wang Nam Khiow and Pak Tong Chai), around Kasetsart University´s Forestry Student Training Station in Nakhon Ratchasima Province, were chosen at random. In the year 2000 Nakhon Ratchasima Province had a population of 2,565,685 people with a median age of 29 years and a sex ratio of 97 (males per hundred females). Sixty-six percent of the population worked within the agricultural sector and 31 % of the population was self-employed, 33 % was employees and 36 % were unpaid family workers (UNESCAP 2000). The two districts covered an area of 2,504 km^2 with a total of 296 villages and a population of 156,576 people, of whom 64 % were between 15 and 59 years old (UNESCAP 2000). While population data for the individual study villages was unavailable, average village size was therefore 534 persons (ignoring the fraction of the population living in cities). The national forest area in the vicinity of the villages was mainly composed of dry deciduous dipterocarp forest, which is characterised by a limited soil layer on a rocky surface. The result is a landscape with low tree density, an open canopy and sparse and dry undergrowth affected by regular fires. Due to the open canopy and limited tree height it is easy to detect and harvest *O.*

smaragdina nests in this habitat. In the seven villages all people collecting *O. smaragdina* were interviewed using structured questionnaires. The questions were centred on methods used to collect ants, yields, location of activities (spatially and temporally), challenges associated with the profession and the economy associated with ant harvesting. The questionnaire survey was conducted by Wissanurak Sribandit between 1 March and 30 April 2006 and all questions referred to ant harvesting activities carried out by ant collectors during 2004 and 2005.

Secondly, more than ten ant harvesters were observed in the field in April 2006, February 2007 and April 2007 in order to describe the methods used to harvest the ants. Variation measures (±) given in the results refer to standard deviation. The currency exchange rate used between THB and US$ was 1:0.02936.

RESULTS

In the seven villages a total of 25 people between 41 and 62 years were harvesting ants (mean = 3.57 ± 4.12 persons village^{-1}). Given an estimated 349 in each village within the age group 15 to 59 years (an overestimate as some of these worked in cities), at least 1 % of the working population was harvesting ants. Four collectors were men, 21 were women and the average size of their households was 4.6 (±1.89) persons. All 25 persons were interviewed for the study. Ants were harvested mainly in national forests, where 76 % of the harvesters collected ants, and secondly in villages and farm areas, where 40 % collected ants. Only 8 % harvested ants in plantation areas (percentages exceed 100 since some people harvest in more than one type of habitat). Assuming the seven villages' ant 'catchment area' was an equal share of the two districts, the 25 collectors used an area of approximately 59 km^2.

Ant harvesting techniques

All collectors used the same method to harvest ants: ants were harvested from the early morning when the ants were least active and until midday. A long (6-10 m) bamboo stick with a net mounted close to the pointed tip was used to pierce the *Oecophylla* leaf nests. When the bamboo stick was shaken, imago worker ants (hereafter called workers), imago virgin queens (hereafter called virgin queens) and brood dropped into the net (Figs. 1-3). From the net the ants were poured into a bucket with water enabling the collectors to separate the different ant castes and developmental stages. Workers were separated from virgin queens and imagos were separated from the brood which comprised both larvae and pupae (Figs. 4-5). After separation the ants were either kept in a refrigerator or stored in water at ambient temperature. In this way it was claimed that ant brood could stay fresh for up to 12 days. As a protection against ant bites, collectors used rubber boots powdered with fine starch powder. The combination of rubber and fine powder prevented the ants from crossing the boots. The same powder was also used on hands and on the bamboo stick to impede ant attacks. The ant harvest started in January when 16 % of the collectors were active, peaked in February-April when 80-92 % were active, and ceased in May during which only 8 % were collecting ants. Outside this season none of the collectors harvested ants.

Harvest yields

When collectors were asked to estimate their daily yields they reported that the harvest per working day averaged 2.88 (± 1.78) kg brood, 1.58 (± 1.45) kg virgin queens and 0.08 (± 0.39) kg workers (only one person reported harvesting workers, at 2.0 kg workers day^{-1}), resulting in a daily total of 4.54 (± 2.24) kg ants collector^{-1}. When asked to estimate their harvest yields by month and summing these numbers, it emerged that brood yield peaked in February-March whereas virgin-queen yield peaked in April (Fig. 6). In total the collectors harvested an estimated 5486 kg ants year^{-1}; thus each person collected on average 219.4 (± 107.5) kg ants year^{-1} (or season^{-1}). Each collected ants on an average of 48 days ((5486 kg / 4.54 kg/day) / 25 ant collectors)) during the season. Assuming 254 working days in a year the average time spent by collectors on ant collection thus equalled 19 % of the working year. However, the collectors did not spend the whole day but on average only 4.48 (± 1.73) hours working-day^{-1} on the collection of

Fig. 1. A Thai ant collector harvesting an *Oecophylla* nest on a mango tree.

Fig. 2. Harvesting net filled with freshly collected ants.

Fig. 3. An ant collector separating workers from brood by dusting the ants with starch powder on a tray. Worker ants seem to be repelled by the powder, and try to flee without the brood.

Fig. 4. Ant collectors processing the harvest: separating workers from virgin queens and imagos from brood (larvae and pupae).

Fig. 5. The final fresh product of queen larvae and pupae ready for the market.

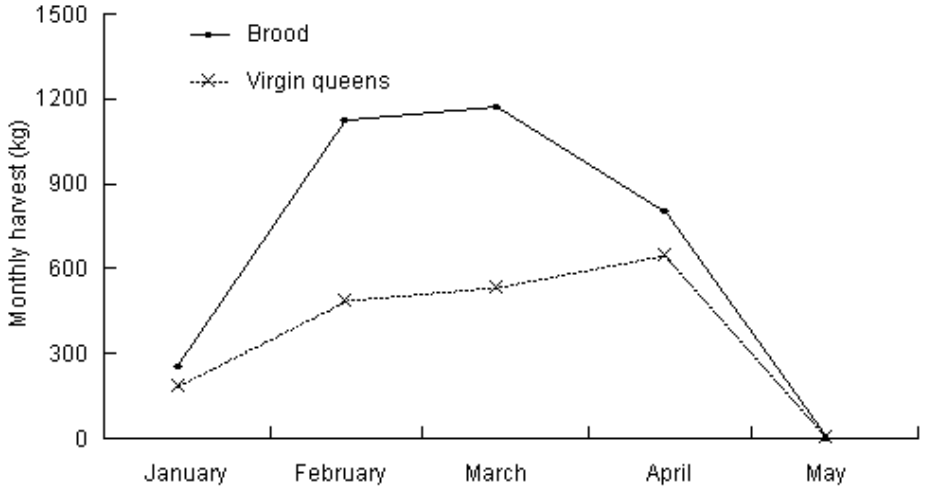

Fig. 6. The weight of harvested ants by month. The figure shows the sum of the monthly estimates given by all the 25 ant collectors, averaged from 2004 and 2005.

ants (ignoring the time spent selling the ants in the market, which was not recorded in this study) resulting in 10-11 % of the working year.

Trading and selling prices

Nine collectors sold all their harvest at markets, four used the entire harvest for the family, one sold all in the village and one sold all to middlemen. The remaining ten collectors sold their harvest to more than one purchaser. On average ant collectors estimated that 50.6 (± 18.2) % (219 kg year^{-1} x 0.506 = 111 kg year^{-1}) of the harvest was sold at town markets, 22.4 (± 41.1) % (= 49 kg year^{-1}) was eaten by the family, 13.2 (± 33.4) % (= 29 kg year^{-1}) was sold in the village, 10.2 (± 39.0) % (= 22 kg year^{-1}) was sold to middlemen and 3.6 (± 0.0) % (= 8 kg year^{-1}) was sold to restaurants. The market price of brood and virgin queens ranged from 100-200 THB (US$2.94-5.87) kg^{-1} with higher minimum prices at both ends of the season; in January and May minimum prices were between 120 and 180 THB (US$3.52-5.28) kg^{-1} depending on the year. The interview data lack information on the price of workers, but we observed workers being sold for 50 THB (US$1.47) kg^{-1} at the market in Pak Tong Chai. In general the highest prices were obtained at the town markets (~200 THB) whereas middlemen, restaurants and people from the villages paid less. In one case a collector obtained 180 THB kg^{-1} when selling to a middleman and 200 THB when selling at the market.

Costs and income

Among the ant collectors the lowest reported total cost associated with ant harvesting was 30 THB (US$0.88) working-day^{-1} whereas the highest was 550 THB (US$16.15) working-day^{-1}, with time (52 %, calculated based on the minimum daily wage and the fraction of the day spent collecting) and travel costs (47 %) making up 99 % of the total and equipment making up only 1 % (Table 1). Travel costs to ant sites were more costly (29 %) than travel to markets (18 %); collectors travelled between 0.1 and 80 km to ant sites with an average of 16.5 (± 21.69) km working-day^{-1}. Among the ant collectors the total gross yearly income of the household ranged between a minimum of 18,000 THB (US$528) and a maximum of 115,000 THB (US$3376) (mean = 67,154 ± 27,652 THB, = US$1971 ± 812), whereas the yearly gross income from ant harvesting ranged from 4,000 (US$117.4) to 50,000 THB (US$1468) (mean = 19,884 ± 13,317 THB, = US$584 ± 391) (Table 2). For individual collectors the yearly income from ant harvesting thus constituted between 10 % and 69 % of the total yearly income with a mean of 30 % (Table 2). Based on the yearly income and average number of working days the daily gross and net incomes from

the ant harvest equalled 411 THB (US$12.07) and 236 THB (US$6.93) working-day^{-1}, respectively. In Nakhon Ratchasima Province the legal minimum wage (and the wage often paid to manual workers) equals 162 THB (US$4.76) day^{-1} (8 hr). Thus the net income from ant harvests was approximately 1.5 times the minimum wage for the province, or 2.6 times if it is considered that only 4.48 hours working day^{-1} were spent on ant collection.

Table 1. The costs (in Thai Baht, THB) associated with ant harvesting. Costs are calculated per working day.

SD = standard deviation.

Costs in THB	Mean	SD
Equipment	1.93	1.77
Travel to ant sites	51	63.84
Travel to markets	31.72	16.56
Time cost[1]	90.72	44.57
Total	175.37	

[1]Time costs were based on the minimum salary for Nakhon Ratchasima province which was 162 THB day^{-1}(8h).

Constraints

Eighty-four percent of the collectors reported finding it increasingly difficult to harvest ants compared to earlier years. Among these 76 % considered an increasing number of ant collectors problematic, whereas 24 % found increasing travel distance a problem and 8 % had problems with obtaining permits. On the other hand, all collectors found it easy to sell their harvest. Forty-eight percent of the interviewed collectors were interested in establishing commercial ant farms to make collection easier and more profitable (52 % showed no interest) but only 12 % had ideas about how to develop ant farming.

DISCUSSION

Economic importance

On average more than three people per village (at least 1% of the working population) collected ants, each collecting almost 220 kg of ant brood during the 4-5-month ant harvesting season. The ant-harvesting income constituted on average 30 % (Table 2) of the collectors' yearly household income, yet collecting ants took up only between 10 and 19 % of a working year; thus the earnings from the ant harvest exceeded those of other activities for an average collector. Daily net income from ant harvesting was 1.5-2.6 times higher than the minimum daily salary for the area. If these figures are typical for villages of the province, wild *Oecophylla* collection is currently worth some 21 million THB (US$620,000) per year in Nakhon Ratchasima. Furthermore, not only collectors were supported by the ant trade. Despite the high price of ant brood (200 THB kg^{-1} at markets compared with chicken, pork and beef with price ranges of 60-70, 90-100 and 100-120 THB kg^{-1}, respectively) ants were easy to sell and trading via middlemen and restaurants generated incomes to these other links in the trading network. Additionally, the harvest constituted a substantial part of the family food intake with an average consumption of 49 kg of ants per season in each collector family. We therefore conclude that the harvest of *Oecophylla* ants in the Nakhon Ratchasima area supports a substantial part of the local community, yielding above-average cash income and important nutrients. The importance of the ant trade to local labour is further pronounced by the timing of the season which is at the end of the dry season when the need for farming labour is minimal and thus alternative incomes are low.

Sustainability

The 25 collectors harvested more than 5 tonnes of ants per season from a roughly-estimated catchment area of 59 km^2; this translates to 93 kg km^{-2} season^{-1}. Harvesters reported they had no impression of a decline in the number of ant colonies in the area. This observation suggests that the harvest at present is sustainable. One reason is the Thai preference for the large virgin queen ants. They only harvest during the queen production season and only collect from the largest nest where the queen brood is located. Smaller nests, where the founding queen and worker brood is located (Peng *et al.* 1998), are not harvested from the colonies. The worker ant population is therefore only marginally reduced and the founding queen rarely damaged. Thus, the

Table 2. The estimated total yearly household incomes and incomes from the ant harvest for individual ant collectors, in Thai Baht (THB). Empty entries show collectors that were unable to estimate their yearly income from ant harvest. F = female, M = male.

Ant collector	Gender	Total income (THB)	Income from ant harvest (THB)	Ant income / total income
1	F	18,000	-	-
2	F	24,500	5,000	0.20
3	F	25,000	4,000	0.16
4	F	38,500	4,900	0.13
5	M	40,200	5,500	0.14
6	F	46,100	-	-
7	F	52,000	5,100	0.10
8	F	71,000	12,000	0.17
9	F	75,500	13,500	0.18
10	M	67,000	16,500	0.25
11	F	75,000	12,500	0.17
12	F	79,000	13,500	0.17
13	F	80,000	-	-
14	F	69,000	15,500	0.22
15	F	55,000	30,500	0.55
16	F	60,000	31,500	0.53
17	F	45,050	31,000	0.69
18	F	50,000	-	-
19	F	85,000	32,500	0.38
20	F	115,000	30,300	0.26
21	M	95,000	32,000	0.34
22	M	105,000	50,000	0.48
23	F	98,000	-	-
24	F	110,000	-	-
25	F	100,000	32,000	0.32
N		25	19	19
Average		67,154	19,884	0.30
SD		27,652	13,317	0.17

colony survival are maintained. In contrast, the newly produced queens (and males) are not essential to colony survival since they eventually leave the colony for mating and establishment of new colonies; the newly mated queens can be collected individually or in small clusters in the vegetation during the mating season. This is also supported by our observations (Offenberg & Wiwatwitaya, unpublished data) that the harvest of ants in an experimental mango plantation in the same area did not affect worker ant densities negatively; all harvested colonies were still present after one year and worker ant densities were actually higher in harvested compared to un-harvested colonies.

On the other hand, the number of ant collectors was increasing. Inexperienced newcomers may, in order to increase yield, adopt harvesting techniques (for example harvesting small nests) that do not consider sustainability. We do not have information on how long ant collection has been practised in the area, but it is believed to be for many generations, and certain traditional practices have been beneficial to sustainability. For example the normal size of the holes in the collecting net enables the majority of workers and worker brood to escape. However, some collectors used densely woven material with the result that all the contents of the nests would be collected. Also, new ant collectors may be unaware of the ant's biology. They could harvest more than one ant territory at a time with the result that workers from different colonies become mixed and start fighting inside ant territories. This may again reduce worker densities and leave the colonies with weakened defences, as well as

introducing hostile non nest-mate workers in proximity to the founding queens and thereby putting them at risk. A high economic incentive to harvest ants as documented in this study will probably result in a steadily increase of ant collectors and increasing competition. Thus, higher harvest pressures and temptations to adopt unsustainable harvesting methods may result. It is therefore likely that the natural ant population may be put at risk in the future as it has been seen in Java where *Oecophylla* ants have become scarce in some areas due to high harvest pressures (César 2004; Suputa, Faculty of Agriculture, Universitas Gadjah Mada, Indonesia, personal communication December 2005). The increasing numbers of ant collectors, long travel distances and associated costs have made accessibility to ant sites an important economic parameter.

Ant farming

Ant farming may become a possible solution, to both future over-harvesting of natural populations and increasing costs associated with travelling to ant sites. By limited intervention it is possible to establish or increase ant yield in nearby crop and non-crop trees. If trees are not sprayed with insecticides *Oecophylla* colonies may establish naturally (they occur on most mango and pomelo trees in the vicinity) or, alternatively, they may be artificially introduced (Peng *et al*. 2004). Subsequent separation of neighbouring colonies to prevent fighting (Peng *et al.* 1999) and the provision of food and water may then increase the yield of harvestable queen brood and generate a profit (Offenberg & Wiwatwitaya unpublished data). Even in fruit plantations ant farming may be profitable since *Oecophylla* spp. can protect a variety of crop trees against pest insects (Way & Khoo 1992; Van Mele 2008 [but see Tsuji *et al.* 2004] and because the harvest does not markedly reduce the densities of worker ants (the caste that patrol the trees for pests). It follows that biocontrol by *O. smaragdina* may be retained under ant harvesting regimes. The establishment of ant farming may reduce costs not only by creating high-density ant sites closer to villages but also by making the harvest of ants less time-consuming, since cultured trees are usually smaller and thus more easily accessible than trees in natural forests, where the majority of the harvest (76 %) is collected at present. The active farming of ants may thus reduce the pressure on natural populations. This view is supported by the 48 % of collectors who showed interest in ant farming. Development of ant farming thus offers an option to maintain economic and ecological sustainability in ant harvesting.

Parallels between Thai and Indonesian *Oecophylla* harvesting

To our knowledge only one other study has described traditional *Oecophylla* harvesting in detail (César 2004). As outlined in the introduction César (2004) describes the harvest of *Oecophylla* brood in Indonesia where ants are used as bird food. According to César (2004) the Indonesian harvesting technique was almost identical to the Thai technique using long bamboo poles with a net to harvest the ant nests. In Indonesia, though, collectors reported that the high-quality brood (worker brood) could only be stored for approximately two days whereas the Thais claimed to be able to store brood for up to 12 days. This difference may arise because the Thais refer to the storing of virgin-queen brood whereas Indonesian collectors refer to the storage of worker brood. Actually, the Indonesians mention that larger larvae can be stored for longer. In both countries the production of sexual brood seems to take place during the dry season, but Indonesian collectors regard the wet season with worker brood as the high-quality season whereas the Thais in this study only harvest ants during the dry season, when virgin queens are produced. Daily yields from the dry season are similar between the countries with an average of 2-5 kg per person per day in Indonesia in comparison to the 4.5 kg reported from the present study. In the wet season when the ant larvae are smaller the daily Indonesian average was 1.5 kg. A striking difference between the two markets was in the market price of ant brood. The consumer price was similar in the two countries, at approximately US$5 kg^{-1} (if the THB-US$ conversion rate is corrected to the 2004 rate = 0.025). However, Indonesian collectors obtained only US$1.2-1.4 kg^{-1} when they sold their harvest to middlemen. In contrast Thai collectors only used middlemen for a minor part (14 %) of the harvest

and the price difference between middlemen and local markets was small (11 % difference in one case). The high price difference in Indonesia is probably based on the long distance between ant sites and consumer markets which are mainly situated in larger cities. Therefore middlemen with high transportation costs are needed in the Indonesian trade chain. Both Indonesian and Thai collectors could easily sell all their harvest quickly indicating high demand in both countries. Consumers in Indonesia were reported to have to wait for their produce to arrive. Due to high demand Indonesian collectors also reported increasing competition for the resource and newcomers to the profession as well as old collectors often disregarded the former harvesting techniques developed to ensure sustainability. For example, harvesting rotation intervals were being violated with the result that *Oecophylla* was becoming scarce in several exploited areas on Java.

Implication for biocontrol

Often the biting of *Oecophylla* ants is a major complaint envisaged by plantation managers when advised to use the ants for biological control and this may hinder implementation of this environment-friendly technology (Van Mele 2008). It is worth noting that the Thai ant collectors described in this study have been able to develop techniques to avoid unacceptable levels of ant bites, even though they are disturbing the ant nests which are the most fiercely protected part of the ant territory. The ant collection methods developed by the Thais may be utilised to avoid ant bites among plantation workers in *Oecophylla*-protected crops and facilitate the implementation of *Oecophylla* biocontrol (Van Mele, Cuc, Seguni, Camara & Offenberg, unpublished data).

Future directions

In conclusion, the harvest of *Oecophylla* ants in Northeast Thailand is substantial and not only for local subsistence but an effective way of earning cash. There is an economically-driven, increasing interest in harvesting ants and thus increasing pressure on natural ant populations. Ant farming may be a solution to retain sustainability and at the same time enhance profitability. Further studies are needed to develop ant farming and test the profitability of different management practises. They include identifying the ants' food requirements (carbohydrates vs. protein) and the food conversion efficiencies of different kinds of food, locating easily-accessible, cheap and sustainable protein sources, and investigating impacts on existing biotic communities, including populations of other economically beneficial invertebrates. Also, studies examining the effect of ant harvest pressures on local ant populations are needed to verify the sustainability of the present activities.

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