Multiple sources of local knowledge: a global review of ways to reduce nuisance from the beneficial weaver ant *Oecophylla*

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Abstract: The weaver ants *Oecophylla smaragdina* and *O. longinoda* are abundant in tropical Asia, Australia and Africa. Although local people and a handful of scientists appreciate the benefits these tree-dwelling ants bring in terms of medicinal and food source, protection of tree crops, and enhancement of fruit and nut quality, *Oecophylla* has one major drawback: it also bites people. Perception of this nuisance, and the response to it, is influenced by the frequency of encounters and the perceived benefits gained from *Oecophylla*. We used a range of methods in more than ten countries to document how people reduce weaver ant nuisance, including interactive rural radio programs. Apart from growers, also ant brood collectors, fruit-pickers and intermediaries

in the value chain hold in-depth ecological knowledge on weaver ants. Ways to make *Oecophylla* more widely accepted and build ecological literacy at various levels of the society are discussed.

Keywords: *Oecophylla*; local knowledge; learning; communication; ecological literacy; agricultural resources; governance.

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Nguyen Thi Thu Cuc is Professor of Entomology in the Department of Plant Protection at Can Tho University, Vietnam, where she has been working for the past 30 years. Her research field is IPM on fruit plants. She has a special interest in biological control and has been studying the weaver ant *Oecophylla smaragdina* since 1992. She is author of the book *Pests of Major Fruit Plants in Southern Vietnam and their Management*.

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Joachim Offenberg is an Entomologist specialised in insect-plant interactions. He obtained his PhD from the University of Aarhus in Denmark in 2004, where he is currently working as a Post Doc. He teaches various zoological and ecological courses at the University and supervises students in biology. For his PhD field work and Post Doc studies, in collaboration with Kasetsart University in Thailand, he developed and optimised methods for the use of *Oecophylla* in biological control and in ant farming in South East Asia. In 2008, he started testing the potential of *Oecophylla* bio-control in Senegalese mango plantations.

1 Introduction

Local knowledge is increasingly being recognised as a crucial human resource to advance development. The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) was a unique international effort to evaluate the relevance, quality and effectiveness of agricultural knowledge, science, and technology. From 2005–2007 it involved 900 participants from 110 countries. The IAASTD emphasised the need to revalorise local knowledge and apply an interdisciplinary approach to knowledge production and sharing. Actions proposed included incentives for and development of capacity among scientists and formal research organisations to work with local people and their organisations. "Success also depends on the extent to which international developments and events drive the priority given to development and sustainability goals and the extent to which requisite funding and qualified staff are available" (IAASTD, 2008).

Large economic losses due to a complex of African fruit flies, aggravated by recent outbreaks of a devastating new fruit fly, *Bactrocera invadens* (Vayssières et al., 2005) has boosted donor support to search for appropriate solutions. The tree-dwelling ant *Oecophylla* is effective in controlling fruit flies and is a pro-poor technology that is readily available to farmers (Van Mele et al., 2007) (Figure 1). However, most governments are unaware of this and in some cases received skewed information from scientists. Most research on fruit fly control has focused on high technologies, such as parasitoids, baits and fruit fly traps that are unlikely to become available to resource-poor farmers (Van Mele et al., 2007). While initial arguments to classify *Oecophylla* as a pest often mentioned ant attendance on homopterans, some scientists bluntly admitted that the ants interfered with their research on parasitoids. So whose knowledge counts? And how can donors and governments be better informed about all the potential options, including local ones that differ from those presented by scientific lobby groups?

As weaver ants seem to be the principal readily available pro-poor technology to control fruit flies in sub-Saharan Africa, it is disturbing to notice that across the continent weaver ants are frequently killed by uncontrolled bush fires, by individuals destroying nests or even by pesticide spray campaigns supported by governments. The general lack of ecological literacy on conservation biological control urges for quick action to get *Oecophylla* widely accepted as a highly valuable resource.

Apart from protecting tree crops from pests in Asia and Africa (Van Mele, 2008a), weaver ants also improve the quality of cashew nuts (Peng et al., 1995), citrus (Barzman et al., 1996) and mango (Sinzogan et al., 2008). Although scientists often consider ants as pests because they tend honey-dew producing insects, such as scales and mealybugs, some women fruit-pickers in Benin considered scales as an indicator for quality: mangoes from trees with scales and weaver ants being sweeter and having a longer shelf life. With regard to weaver ants, opinions are divided and irrespective of their appreciation of weaver ants, most farmers want to reduce the ants' nuisance during farm operations. Although the bite of *Oecophylla* is not particularly painful and the pain disappears within seconds (Hölldobler and Wilson, 2000), weaver ants can be a nuisance and such feelings are likely to be stronger when one is not fully aware of the benefits the ants bring. Across Africa and Asia, farmers' and labourers' implicit demand is about addressing the ants' nuisance.

Figure 1 Weaver ants construct their nests in trees by weaving living leaves together (see online version for colours)

To accommodate farmers' needs, all knowledge sources need to be mobilised, the relevant knowledge repackaged and shared with the wider community. As a first step in this direction, this paper provides a global overview of local practices to reduce nuisance

from the weaver ant. Country case studies are followed by a conceptual framework describing key factors influencing people's perception towards and governance of this under-utilised natural resource. The discussion addresses strategies and challenges of building ecological literacy. We conclude by proposing the scope for future innovations to boost acceptance of *Oecophylla* in tree crops.

2 Methodology

The data was collected for countries previously documented to use the weaver ant or for countries where this was recently 'discovered' to be the case. The methods varied by country but generally included one or more of the following: surveys, interviews, observations and ad-hoc enquiries to persons requesting the widely-circulated *Ants as Friends* book (Van Mele and Cuc, 2003). This book was subsequently translated in Bahasa Indonesia, Vietnamese and French, and widely distributed via informal and formal networks. Summaries on the websites of Eco-Innovation, New Agriculturist, Pesticide Action Network, FFSnet and Spore magazine (no. 83) further added to its popularity. Personal requests for copies of this book were always followed by the authors enquiring about what farmers in their country did to reduce the ants' nuisance.

In 2006 and 2007, Van Mele obtained a grant from the US-based Conservation, Food and Health Foundation to start activities with ant-based pest control in tree crops in Benin, Guinea and Tanzania. Surveys conducted by national partners included questions related to people's perceptions and local techniques to reduce ant nuisance.

Over the past 15 years, the authors also interviewed scientists, extension workers, ant brood collectors, fruit growers, pickers, pisteurs (intermediaries) and fruit exporters in Burkina Faso, Mali, Vietnam, Thailand, Indonesia, Malaysia and Australia. Details of the documentation methods are presented on a country by country basis, alongside contextual information of relevance to this study.

3 Case studies

3.1 Benin

Fruit production in Benin is entirely for the local market. Growers are not organised into associations and national and rural institutions supporting the fruit sector are hardly developed. In 2007, 55 growers were interviewed and discussions held with five groups of pickers, comprising rural women and children. All growers had established their orchards as a form of retirement insurance. Those involved in on-farm research changed their negative attitude towards *Oecophylla* when they learnt about the ants' importance in reducing fruit fly damage (Sinzogan et al., 2008).

Surprisingly, fruit-pickers who are more exposed to the bites of *Oecophylla* ants had a more positive attitude to the ants than the plantation owners. This can be explained by looking at the economic arrangements made between orchard owners (or their farm managers) and fruit-pickers. During harvest fruit-pickers move from one orchard to the next. Generally, teams of mother and daughter harvest the fruit in selected parts of the orchard. The women select the best fruit on the spot. Once finished, all pickers gather their harvest and negotiate a price with the owner. When the deal is closed, the women

transport the mangoes to the local market where they try to sell the fruit. Clearly, they have a direct economic stake in selecting the best fruit. Fruit attacked by fruit flies (which is hard to see the first day after the damage has been inflicted) will spoil rapidly.

Figure 2 Women in Benin use long picking poles to harvest mangoes and avoid nuisance from weaver ants (see online version for colours)

During the survey, growers and pickers reported only a few techniques for avoiding ant bites during harvest, of which the use of a long picking pole was most common (Figure 2). Very few pickers cited other techniques such as climbing the trees to pick the fruit at the hot time of the day when ants are less active; or putting ash on the exposed parts of the body before climbing the tree. Some eradicate ant nests physically or with fire (Sinzogan et al., 2008).

In May 2008, two programs were broadcasted on Radio Immaculée about the benefits of weaver ants and ways to reduce nuisance. People were invited to call in. In no time nine local innovations were documented, such as burning palm fronts underneath trees to create a mild smoke after which ants return to their nests. Some put on clothes that beekeepers wear when collecting honey.

3.2 Guinea

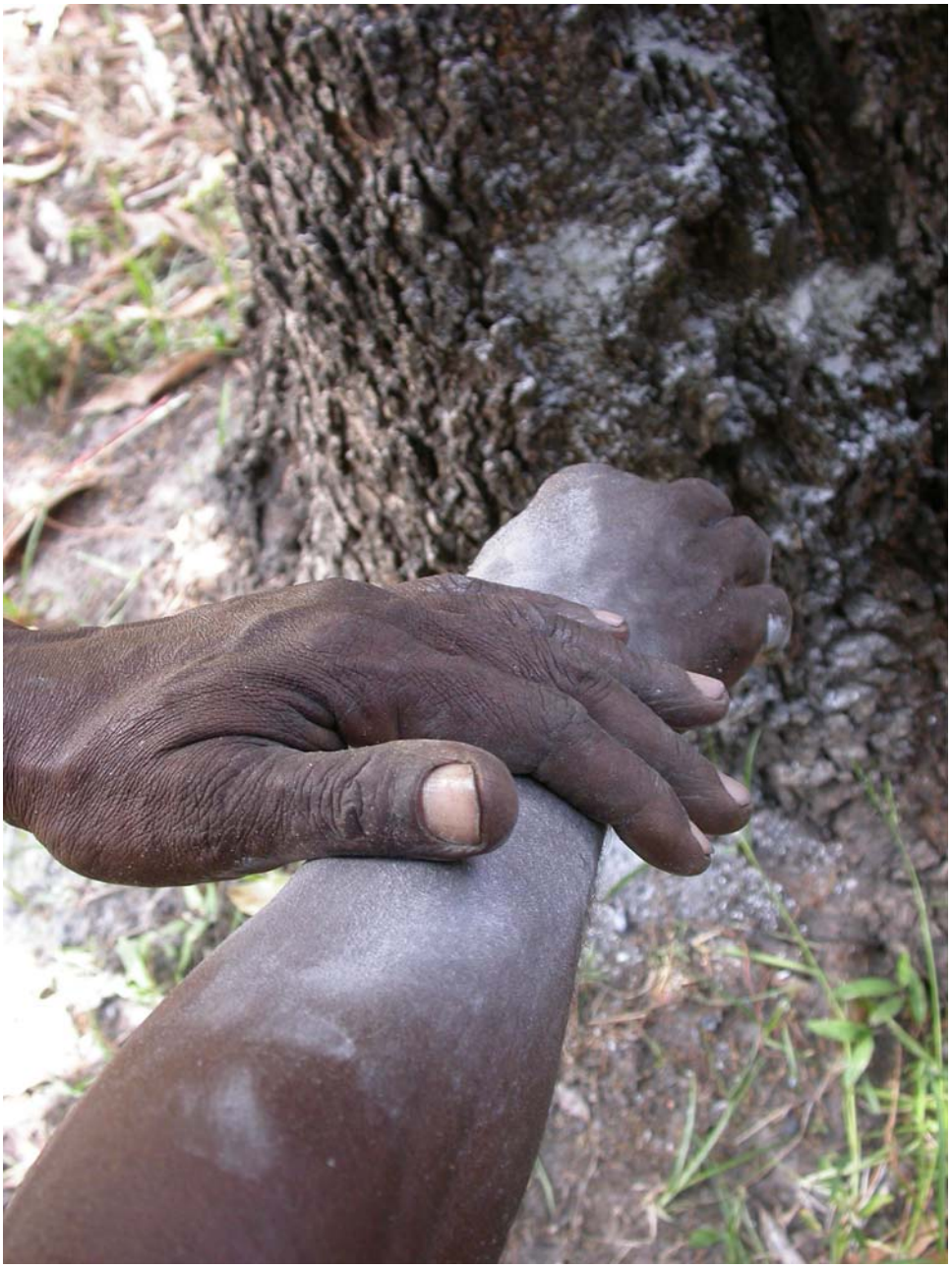
In Guinea, only one global trading company (SIPEF) exports mangoes to European supermarkets. It abides by the Good Agricultural Practices set by the European Retailers' Association (EUREPGAP) by cashing in on the fact that most local production is organic by default. Also, business people from Côte d'Ivoire regularly cross the border to buy up entire harvests, sometimes arriving with their own picking teams.

In 2006, plant protection staff interviewed 100 tree crop growers in the major horticultural zones of Guinea, including Kindia, Kankan and Boké. Apart from chasing away snakes, about 46% of the growers mentioned that weaver ants reduce damage by fruit-eating bats (Van Mele et al., 2009). Because *Oecophylla* bites harvesters, up to 42% of the farmers spontaneously mentioned *Oecophylla* as a pest. Nearly all requested the help of the staff to treat their orchards with pesticides even though over half of the farmers knew the ant preyed on pests.

About 57% of the growers interviewed reported that *Oecophylla* had a positive effect on mango quality, such as higher sugar content. Reasons given for improved quality varied from ants depositing their eggs on the fruit (6%), ants protecting the fruit from pests (24%), and because fruit in orchards with ants is allowed to ripen before being picked (26%). In previous interviews women told Van Mele that the quality and production of mango, citrus and kola (*Cola acuminata*) was more elevated when weaver ants were present. In the latter crop, people think that ants improve flowering. The kola nut, originally used to make cola soft drinks, is commonly chewed and presented to guests in West Africa. The nut has recently found a niche market. In 2007, the UK supermarket Tesco introduced a US premium cola that uses kola nuts.

From the 100 mango and cashew growers interviewed, 38 did not do anything to reduce nuisance from ants, whereas 20 applied wood ash and 19 smeared petrol on arms and legs before climbing the trees (Figure 3). 11 used a picking pole and six cleaned the vegetation around the trees before harvest. Four farmers wore protective clothing, such as rubber boots and gloves and two reported just sweeping away the ants from their legs with branches and leaves.

Figure 3 Farmers across Africa and Asia apply wood ash on arms and legs before climbing trees with weaver ants (see online version for colours)



During a workshop with scientists and a few growers from various parts of the country, Van Mele facilitated the development of discovery learning exercises for use in farmer training programs. One of which was on reducing ant nuisance. The team came up with as many as 22 different technologies (Table 1).

Table 1 Local technologies to reduce ant nuisance in Guinea

Methods	*Observations*
Mechanical avoidance	
Use a long picking pole	Common practice in Fouta
Use a ladder to harvest (traditional, pliable)	To allow avoiding the ant nests
Wear long sleeves tightly closed around wrist and do the same with bottom of trousers	Common practice in Lower Guinea
Use gloves and rubber boots	Common practice in Lower Guinea
Mechanical repulsion	
Rub wood ash on arms and legs	Applied before climbing tree, it will make rubbed body parts slippery to ants and avoid them biting
Apply wood ash on ground around tree trunk	To avoid ants from coming down when fruit is harvested from ground
Olphactorial repulsion	
Apply water in which pulverised cassava leaves have been soaked to body parts	This is also used to treat bee stings and to chase away driver ants (*Dorylus nigricans*)
Apply fresh cassave leaves	To repulse driver and weaver ants
Apply salted solution to exposed body parts	To repulse driver and weaver ants
Smear juice of citrons on body	To repulse weaver ants and leeches
Smear petrol on arms and feet before climbing trees	Common practice
Destructive	
Spray insecticides on leaves and ground before harvest	Commonly practiced in industrial plantations
Destroy ant nests prior to harvest	To reduce the ant population
Use a straw torch	To chase away the ants with smoke or kill them with the fire
Ecological consciousness	
Avoid disturbing ant nests during harvest	To avoid ants becoming aggressive
Harvest at time when ants are calm	Especially the early morning and hottest part of the day are most suited
Mental strength	
Dissuade ants	Calmly blow on ants to deter them from biting
Be courageous	To face the challenge
Self-defense	Sweep away the ants with your hands or a twig
Briskly shake the tree	To quickly harvest; not done for export mangoes
Baits	
Place left-overs from chicken or chicken intestines around tree trunk	To attract ants to the ground before climbing trees

In November 2007, Van Mele had the opportunity to talk to Mr. Toure Yaya, responsible for quality control at the fruit exporting company, SIPEF, and one of his pisteurs. Pisteurs are typical intermediaries in the value chain for export mangoes in Guinea, Burkina Faso and Mali (Vannière et al., 2004). Mainly based on the quantity of fruit (number of boxes) harvested, they negotiate the price with the growers, after which they arrange to transport the fruit to the mango processing station. Pisteurs also organise and train teams of local fruit-pickers with whom they negotiate wage conditions. When weaver ants are abundant, fruit-pickers tend to negotiate for a higher wage. Interestingly, the pisteur is often willing to pay more, because he knows the quality of the fruit is better. What matters for him is the quality of fruit delivered to the station, as he will only get rewarded for those fruits judged suitable for export by the processing centre. Various pisteurs mentioned washing fresh fish and pouring the water around the tree base: the ants are attracted and descend en masse, making climbing the trees easier.

3.3 Burkina Faso and Mali

Mango is the principal fruit crop in Burkina Faso and Mali, situated in the dryer Sahelian zone. Mali was the first country in the region to begin exporting mangoes around 1970, followed by Burkina Faso, Senegal and Côte d'Ivoire in the 1980s (Rey and Goguey, 1996). Over the years, various traders from Mali and Côte d'Ivoire invested in the mango value chain in Burkina Faso. Burkina now hosts several companies that export mangoes to Europe, including Fruiteq and Burkinature (van der Waal, 2008). Their focus on fair trade and organic production have become driving forces to work with rather than against weaver ants. The authors did not have the opportunity to conduct systematic surveys here; information was collected during various country visits and workshops.

Until recently, the scientific community in West Africa referred to weaver ants as a pest. This perception was mainly fed by the authoritative book on mango cultivation (de Laroussilhe, 1980). When the United Nations Food and Agriculture Organization (FAO) asked Van Mele to facilitate a workshop on weaver ants, the main objective was to train people how to overcome ant nuisance. Participants from Mali and Burkina Faso included staff from a regional farmer field school (FFS) program, the NGO Helvetas, farmer cooperatives, mango growers, fruit-pickers, pisteurs and exporters. Various growers and fruit-pickers reported they killed the ants during the hot season, which is exactly when mango fruits mature and need most protection from fruit fly attacks. They generally cut nests and leave them to scorch on the bare and hot sandy soil. Luckily, the FFS program is building growers' ecological literacy and changing their destructive behaviour towards *Oecophylla*.

In Mali, the Bambara name for *Oecophylla* is *kowulu*, meaning dog of the lowlands. It hints to the perceived aggressive nature of the ants and their preference for the more humid valley bottoms. The Malian Government, unaware of the importance of weaver ants in protecting mango from fruit fly attacks, recommends spraying the trees and nests with insecticides. The Ghanaian Government seems to have a similar disregard to endemic natural control agents: for the last years they organised 'spray gangs' to blanket spray cocoa plantations with insecticides.

3.4 Mainland Tanzania and Zanzibar

In 2007, Seguni and his staff interviewed 55 tree crop owners and five coconut pickers on their knowledge about weaver ants, commonly called *maji moto* (literally meaning hot water). Coconut, mango, cashew, clove (Zanzibar) and citrus were frequently mentioned as giving a better harvest and being protected from noxious pests by weaver ants. The majority also believed the ants had a positive influence on the quality of these crops, whereas less than 10% thought the production and quality was negatively affected. About 95% reported the bites being the biggest problem, with 5% believing the ants invoke fever. Most farmers though said that they protect weaver ants despite their bites due to their overwhelming benefits to crops. Less than 20% braved the ants and ignored the bites, whereas 40% rubbed ash on their body, 28% sprinkled ash on the tree trunk and branches and 11% used protective clothing. Sometimes these techniques were combined with the placement of fish intestines at the bottom of the tree to lure the ants away prior to harvest. Some farmers on the mainland smear kerosene, commonly used in kerosene stoves, onto the hands and bare parts of legs to repel ants.

In Kidole village, mainland Tanzania, Abdi Mussa said that farmers rub their arms and legs with coconut oil or wood ash before climbing coconut trees, the former being most effective. Farmers at times reapply the oil or ash throughout the day. In the morning the ants are less aggressive and their aggressiveness was said to increase in the dry season. Coconut-pickers use home-made coconut oil. The oil is smeared on the exposed body parts to repel the ants. The commonest coconut oil is prepared in homes by women by first grating mature coconuts and using the gratings and water to make coconut milk. This is then boiled slowly to evaporate water at the end of which oil accumulates at the bottom of the boiling vessel.

In Zanzibar, farmers normally collect ash from heaps piled at bakeries. For firing the kilns these bakeries use a variety of forest wood, including *Casuarina*. This wood is very hard and gives very fine white ash, which is said to give the best results. Sometimes even mango branches are pruned to supply fuel wood. For the bakers, ash is a waste product and they give it free of charge to fruit-pickers. On the mainland the ash comes from home kitchens that use various fuel sources, including coconut husks and palm fronts. In this case, the ash is more greyish. Fruit-pickers take a bag of wood ash with them and before mounting a tree they smear their arms and lower legs. The bag is then pulled up by a rope and a handful of ash is sprinkled on the main branch where the picker is positioned. Ants trying to approach will slip and fall off the tree.

The cropping systems and culture in Zanzibar are quite distinct from those on the mainland. Unlike the vast coconut plantations on the mainland, clove or *karafuu* trees commonly grow in the highly diverse gardens in Zanzibar, which resemble the spice gardens from Sri Lanka. Zanzibar is a cultural melting pot between Africa and Asia, and farmers overall have a deep knowledge on weaver ants. As the 70-year old Mrisho Mohidin Mzee from Kinyasini village explained:

> "Weaver ants are most abundant in clove trees at flowering, as the ants get honey from the flowers. When there are no cloves there will be no or few weaver ants, so it is important to have other trees around with ants, because if you do not have *maji moto* (literally hot water, referring to their bites) you will not have *karafuu*."

He continued by carefully explaining that the difference in tree bark structure and architecture determines what techniques work best to reduce nuisance from *maji moto*

(Figure 4). Clove trees typically have upright branches and a smooth bark so ash does not stick. In this case, dried palm fronts are woven into a torch; the end squeezed into splinters and set to fire. Ants are chased back into their nest before climbing the tree. But for large clove plantations, pickers are hired and provided with a canister of insecticides from the agricultural input shop.

Figure 4 Farmers in Zanzibar use a fire torch made of twisted palm leaves (see online version for colours)

Note: The smoke makes ants return to their nest and makes climbing trees and harvesting cloves easier.

In his early days, the 75-year old Mzee Ali Mzee from Dunga Kiembeni village in Zanzibar used to organise labour for the clove harvest in Pemba Island. He was not farming himself and never paid particular attention to whether clove trees with ants yielded more or not, but he still remembers that weaver ants were a hassle as the pickers generally asked 50% more wage to pick cloves from trees with ants. He used fire to kill the ants or sometimes even sprayed DDT.

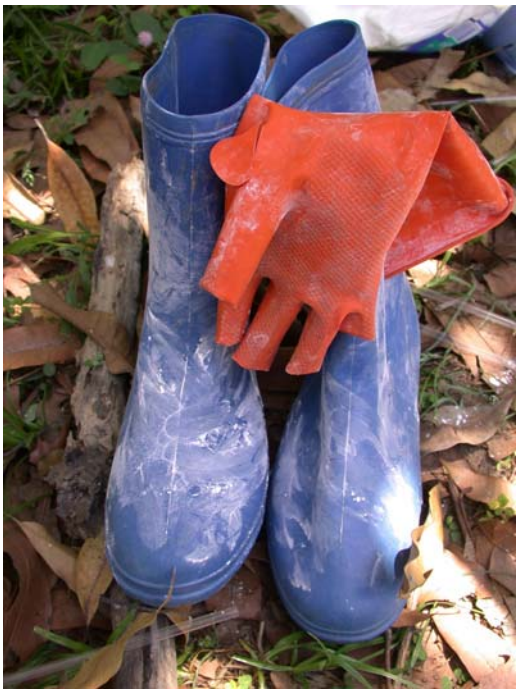
Geoffrey Kirenga (Assistant Director Crop Promotion) and other staff from the Ministry of Agriculture, Food and Cooperatives only learnt about the benefits of weaver ants in fruit crops during a workshop held in 2007 organised as part of the Conservation, Food and Health project. To George Millinga, secretary of the Association of Mango Growers (AMAGRO), this new knowledge came very timely. For the past year, AMAGRO had been trying to purchase methyl eugenol (to trap fruit flies) from Kenya and South Africa, in vain. He also stressed the importance to promote weaver ants in cashew. More and more cashew farmers turn to insecticides and with the cashew industry

being well organised, links could be established with the Tanzanian Organic Agriculture Movement. Premium prices for organic produce can trigger wider acceptance of *Oecophylla*.

3.5 Thailand

In Thailand, people have harvested weaver ants and their brood for food for generations without feeling too annoyed. They do not consider the bites a real problem. Like with beekeepers (although stings from bees are far more painful than a bite from a weaver ant), some protect themselves while others claim the bees do not harm them. The establishment of apiculture furthermore shows that methods can be developed to handle much more painful and potentially deadly insects like bees, making the handling of *Oecophylla* a manageable challenge.

Figure 5 Ant collectors in Thailand apply starch powder made from manioc on their most exposed skin and on their rubber boots to avoid ants from climbing up their legs (see online version for colours)



Ant-collectors normally use a long pole with a cloth or plastic bag at the end and shake it under the ant nests. Their only protection is flour made from cassava or manioc (*Manihot esculenta*), which they put on their arms, the harvesting equipment and their rubber boots to avoid ant attacks from the ground (Figure 5). Also, the harvest starts early in the morning when the temperature is low and the ants move slower and are less aggressive. By using these simple techniques, Thai ant-collectors cope with the highest possible ant aggression brought about by their direct attack on the ants' nests. They cope with it, because ant collection generates 2.5 times higher incomes than the local minimum wage.

The Thais also use cassava flour to separate live workers from the brood. When they sprinkle the living ant biomass containing workers and brood they can actually put their bare hands into the living mass without too many bites. Also the workers will abandon the brood in order to escape the powder. When one of us (Offenberg) used a combination of rubber boots and gloves sprinkled with powder, he was able to bare-handedly dissect a nest without getting a single bite. Fine powder actually seems to work as a general protection against ants, most probably because it affects the functioning of the ants' adhesive pads.

While doing experiments with transferred weaver ant colonies in Denmark, Offenberg and colleagues used potato flour, which also posses a very fine grain size and equally seemed to do the trick.

Figure 6 Ant brood collectors in Indonesia have stamina, patience and do not perceive the ants' bites as nuisance (see online version for colours)

3.6 Indonesia

While organising a workshop on weaver ants in Indonesia in 2003, Van Mele, Thu Cuc and Barzman observed a similar method being used by professional collectors from ant brood or *kroto* (Figure 6). Yet, unlike in Thailand and the Philippines where adult ants and their brood are used for human consumption, in Indonesia the brood is used for songbird food and fish bait. *Kroto* is sold in shops and markets. Weekly songbird contests are an integral part of the local culture and songbirds are said to sing best when fed on brood from *Oecophylla*. A detailed description of the collection and commercialisation of

kroto is provided by Césard (2004). Another in-depth ethnoentomological study focusing on the nutritional and medicinal values of insects in Africa (van Huis, 2002) equally reports on the collection of *Oecophylla* by local people. In neither case were details given as to how people manage ant nuisance during collection.

3.7 Vietnam

In Vietnam, citrus is cultivated from the north to the south, with the Mekong Delta being the largest area. Here, the typical orchard design is evidence of people's ingenuity with regard to land and water management. Alternating raised beds with 1–2 rows of trees are interspersed with canals that are used for irrigation and for small boats to transport the harvest. Citrus farmers in the Mekong Delta have a long tradition in rearing and using *Oecophylla* in their orchards (Barzman et al., 1996).

Despite this tradition in citrus, a survey conducted in the late 1990s revealed that mango farmers on average sprayed insecticides and fungicides 13 and 12 times per year, respectively (Van Mele et al., 2001). Nearly all farmers calendar-sprayed on a weekly basis. Mango trees being much higher than citrus trees affects farmers' observation power. Consequently, very few mango farmers know about the benefits of *Oecophylla* in mango and most reside to pesticide use.

In the 1990s, under pressure from the agrochemical industry, also many citrus farmers started to use insecticides. Especially newcomers who had no previous experience growing mandarin considered *Oecophylla* a nuisance (Van Mele and Cuc, 2000). More experienced citrus growers know how to avoid being bitten by the weaver ant. With an increased interest of foreign markets for organic produce, additional incentives emerged to revive the tradition of weaver ant husbandry.

Fruit-picking is undertaken by the farmers themselves with the help of mainly family labour. To reduce nuisance, many farmers in Ben Tre and Tien Giang province in the Mekong Delta mount a high pressure pump on their boat and spray water from the canals onto the tree canopies prior to harvest. This practice is based on farmers' careful observation that during rains, ants return to their nest. In Cantho City and Hau Giang province, citrus growers bring a bag with 5–10 kg of ash to the orchard and throw wood ash on branches before climbing the trees. The day before harvest, some farmers also reduce ant numbers by spraying soft chemicals, such as Admire (imidacloprid) or Conserve (spinosad). They avoid spraying trees with nests. A less common practice consists of moving nests to trees outside the orchard 1–2 weeks before harvest and removing the ant bridges (ropes or sticks connecting canopies of neighbouring trees). Often farmers do not climb the trees to pick the mango and citrus, but use a long bamboo-stick with scissors and a basket. After the fruit is cut, it falls into the basket. Most use a similar device but without basket. They cut the fruit and let it fall into the water from the surrounding canals after which they are collected.

3.8 Australia, Malaysia and other countries

When studying weaver ant ecology and collecting ant nests for experimental reasons, scientists at Darwin University, Northern Australia, use a veil and gloves – similar to the ones used by beekeepers to protect head and arms from stings (Figure 7). Scientists recommend commercial mango growers to use their tractors to spray water under high pressure prior to harvest (Renkang Peng, personal communication).

Figure 7 Scientists in Australia use protective clothing during their experiments with weaver ants (see online version for colours)

To manipulate ant nests, scientists from the Forest Research Institute in Malaysia (FRIM) tried out various methods.

> "To handle weaver ants, we often wear disposable latex gloves. The weaver ants slide right off and that avoids the hands from being bitten. However, protection is temporary, because when harvesting many nests, the formic acid sprayed from the ants onto the gloves makes them wet. Then the ants will be able to crawl on the glove and up our arms. Now when we harvest, we just do it as quickly as possible and transfer the nests in large dustbins with tight lids. And we harvest in the morning when it is cool and the ants are less active." (Grace Tabitha Lim Wui Oi, personal communication)

The scientists also used a telescopic clipper. Around the middle of the pole they wrapped plastic and smeared 'Cold Foot' (a polybutene bird repellent) on the plastic wrap. This keeps the ants from running down the pole and biting the operator.

In a Senegalese mango plantation Offenberg noted that soil dust during the dry season had an effect similar to the manioc or potato powder used in Thailand and Denmark, respectively. His rubber boots automatically became covered with soil dust which made them slippery to ants and prevented them from climbing up.

4 A conceptual framework

Although other factors may be at play, people's perception of nuisance from *Oecophylla*, and the response to it, seems to be partly influenced by the frequency of encounters between people and ants, and the perceived benefits derived from the ants (Table 2).

Table 2 Behavioural response towards nuisance of weaver ants

	No perceived benefit from ant	*High perceived benefit from ant*
Frequent encounters, often over wide area	Kill ants (e.g. coffee plantation workers; clove pickers paid on basis of quantity, not quality)	Put up with ant nuisance and be courageous (e.g. ant brood collectors in Indonesia; mango-pickers/sellers in Benin)
	Negotiate higher wage (e.g. clove pickers in Zanzibar and mango pickers for export companies)	Prefer orchards with weaver ants and pay higher wage to pickers (e.g. pisteurs in mango value chain in Guinea)
Few encounters	Kill ants (e.g. national governments)	Develop technologies to reduce ant nuisance (e.g. growers and pickers in Asia and Africa; scientists doing experiments with ant colonies)
	Ignore ants (e.g. large plantation owners who have others manage their crop and labour force)	

The entomologist Steyaert (1946) working in Belgian Congo since the turn of the 20th century mentioned *O. longinoda* to be a nuisance to coffee pickers and pruners, who avoided infested trees. In most cases, weaver ants are not tolerated by labourers who do not have a direct economic stake in it. Clove pickers in Zanzibar either kill ants or negotiate higher wage when the density of ants is high.

When people have little exposure to weaver ants and are unaware of their benefits, they either ignore or decide to kill them. This can be the case for plantation owners, but also for governments.

Harvesters of ant brood or *kroto* in Indonesia have stamina, patience and a lot of skill (Césard, 2004). Their daily encounters with *Oecophylla* has given them deep ecological and biological knowledge, but apparently did not lead them to develop many technologies to reduce nuisance. The same was true for ant-collectors in Thailand: they simply do not seem to be bothered too much, indicating that the perception of the ants' nuisance is partly psychological.

Through experience most harvesters of mango, citrus, coconut and clove have learnt that trees with weaver ants yield a better crop and higher quality fruit. Their encounters with *Oecophylla* are only on a seasonal basis and may explain why, rather than having developed endurance such as the kroto harvesters, they have come up with technologies to reduce the ants' nuisance. This is especially the case when the harvesters have a direct economic stake.

5 Discussion

The case studies presented indicate that people respond differently to weaver ant bites depending on the context. To protect and value this beneficial natural resource, building

ecological knowledge within the various strata of society is crucial (Van Mele, 2008b). To overcome the principal hurdle in *Oecophylla* gaining wider acceptance, we reviewed the existing stocks of knowledge with regard to technologies to overcome the ant nuisance. Changes in perception will contribute to building a stronger ecological literacy, which in turn will allow new innovations to emerge, whether technical or institutional.

5.1 Making better use of existing stocks of knowledge

Donors are becoming interested in agriculture again (World Bank, 2008). While also philantropists, such as the Bill and Melinda Gates Foundation, enter the scene, traditional donors realise that more efforts are needed to ensure that existing stocks of knowledge and technologies reach the intended audience. DFID, for example, decided to spend around £1 billion over the next five years on development research. This includes looking at what knowledge already exists, and making it newly relevant (DFID, 2008).

According to Bentley and Rodriguez (2001) folk knowledge is uneven, being determined by the cultural importance of each item and its ease of observation. This partly explains the difference in knowledge between growers and other economic agents in the value chain. Eric Boa and colleagues indicated that apart from researchers and farmers a third neglected group, técnicos or extension workers, can help get a clearer picture of agricultural issues (Boa et al., 2001). This paper illustrates the importance of involving other neglected people when documenting local ecological knowledge. Apart from growers, also ant-collectors, labourers, fruit-pickers and intermediaries in the value chain hold in-depth ecological knowledge. In fact, these economic agents work over larger areas than at the field level and as such developed insights other than those held by individual growers. The authors also learnt that, given the economic importance of their ecological knowledge, they are often reluctant to share it. Having involved them in workshops it became clear that the sharing of their knowledge may trigger community action towards more sustainable agriculture. A diverse range of often context-specific methods can be used in knowledge generation and sharing, as shown by Van Mele et al. (2005) and Scoones et al. (2008).

5.2 Building ecological literacy

As mentioned earlier, the majority of scientists and extension staff have a negative attitude towards *Oecophylla*. Ways need to be developed to better inform highly-educated people about local ecological knowledge. Ideally, this should take place at an early stage. Kimmerer (2002) states that the incorporation of traditional ecological knowledge into the formal education system has "value not only for the wealth of biological information it contains but for the cultural framework of respect, reciprocity and responsibility in which it is embedded".

Despite differences in perceptions within the scientific community, farmers and economic agents across countries claimed that weaver ants have a positive effect on the quality and level of production of fruit, nut and clove trees. Recently, a regional World Bank project on fruit fly control in West Africa decided to include weaver ants as one of the options. In the short-term, donors may be the most important driving force to orient scientists towards locally appropriate technologies.

Opinions also differ within rural and urban communities. Improving ecological literacy at the broader society can in the long-term lead to changes in the likelihood of individuals to engage in collective action, such as organic production and marketing (Pretty, 2008). The rural radio programs on weaver ants, developed in Benin, aim to contribute to those objectives. In Tanzania, a video program has been developed to trigger people to innovate.

5.3 Future innovations

Fundamental research may unveil the principles behind some of the technologies that help people to overcome nuisance from weaver ants. For instance, it is likely that wood ash covers the arolium (adhesive pads at the ants' feet) and thus reduces its adhesive function. If the ash or charcoal is coating the arolium then the adhesive secretion might not work any more unless the arolium is cleaned (Jerome Orivel, personal communication).

But technological innovations are only part of the picture. As perceptions of nuisance are influenced by the economic stake people have in producing quality produce, institutional innovations such as compensating labourers (not just farmers) in fair trade schemes may be equally important (van der Waal, personal communication) or sharing a premium for organic produce with growers, pickers, pisteurs and others along the value chain.

Supermarkets employ codes of standards to assure the uniform safety, quality and 'ethical' content of their food products. These standards may over-ride the kinds of practical, local knowledge long employed in food production and trade (Freidberg, 2007). To modify cultural perceptions towards quality of produce local ecological knowledge may be communicated through short video programs to Western consumers in supermarkets.

6 Conclusions

Multiple sources of local knowledge exist. Apart from farmers, also researchers and development workers with a sympathetic ear to human and ecological landscapes and those who have a direct stake in better managing natural resources, such as pickers and traders may hold in-depth ecological knowledge. This review tapped in these multiple sources to document the various ways in which ant nuisance is reduced during harvesting and maintenance operations in orchards, plantations and forests. Context-specific technical and institutional innovations can emphasise and reward environmental-friendly practices.

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