International Journal of Pest Management
Vol. 54, No. 3, July–September 2008, 241–246

Implications of on-farm research for local knowledge related to fruit flies and the weaver ant *Oecophylla longinoda* in mango production

A.A.C. Sinzogan[a], P. Van Mele[b]* and J.-F. Vayssieres[c]

[a]*Faculté des Sciences Agronomiques, Université d'Abomey Calavi, Cotonou, Benin;* [b]*Africa Rice Center (WARDA), Cotonou, Benin;* [c]*International Institute of Tropical Agriculture (IITA), Biological Control Center for Africa, Cotonou, Benin*

(*Received 7 September 2007; final version received 26 February 2008*)

We interviewed half of the mango-growers in northern Benin, including 15 farmers involved in a regional fruit fly project, and held focus group discussions with women fruit-pickers. They were asked about pest management and their knowledge of a weaver ant, *Oecophylla longinoda*. All considered low yields due to fruit flies to be the principal constraint upon mango production, estimating economic losses to be between 20 and 45%. None could recognize damage during the first 2 days after fruit fly egg deposition. On-farm research persuaded farmers to stop using insecticides and it also changed negative perceptions of *Oecophylla*. Over 80% of the farmers involved in on-farm research, compared to 25% of those not involved, reported *Oecophylla* to be beneficial. All fruit-pickers knew that ants protected mango from fruit flies, with 60% attributing better mango quality in terms of appearance, shelf-life and sweetness to the presence of *Oecophylla*. Nevertheless, 40% of the pickers still considered weaver ants a nuisance pest during harvest. Ways of reducing this nuisance need to be developed for *Oecophylla* to gain wider acceptance by mango-growers.

Keywords: farmer knowledge; labourer; fruit fly; *Oecophylla longinoda*; weaver ants; conservation biological control; on-farm research; mango; Africa

1. Introduction

The livelihoods of millions of African smallholders depend on fruit, nut and agroforestry systems. In Africa as a whole, mango production is estimated to be around two million tonnes (Lux et al. 2003). Because of structural and pest problems, rarely more than 5% of this production is exported (Vayssières et al. 2004). Pest problems are mainly due to fruit flies (Diptera: Tephritidae), which are of increasing economic importance since the introduction of the species *Bactrocera invadens* (Vayssières et al. 2005).

Fruit-growers lack appropriate control methods; some of them even resort to application of pesticides distributed for cotton production. Besides the potential impact on public health, insecticides also affect wildlife and the ecological sustainability and resilience of the farming system. One way of achieving more sustainable production systems is through integrated pest management (IPM). In tropical countries, the successful application of the weaver ant, *Oecophylla* spp. (Hymenoptera: Formicidae), as an endemic natural enemy is on the rise, partly triggered by emerging markets for organic produce, as reported in a recent review (Van Mele 2008). In northern Australia, for instance, biological control with *Oecophylla smaragdina* is promoted in commercial cashew plantations (Peng et al. 1997). In Vietnam, the ants *O. smaragdina* and *Dolichoderus thoracicus* help farmers to control pests in citrus and sapodilla, respectively (Van Mele and Chien 2004). In African farming systems, an abundant *O. longinoda* population can drastically reduce damage from fruit flies (Van Mele et al. 2007). However, until recently the deliberate use of *Oecophylla* in pest management has been mainly put into practice in Asia.

Recent experiences in Ghana and Zanzibar demonstrate the intricacies of transferring a successful IPM model from one region in the world to another. Fixed prescriptions or IPM packages do not work because site-specific agroecological and socio-economic conditions determine what is best in each location (van Huis and Meerman 1997). IPM needs to be driven by farmers' needs and to build on farmers' knowledge. Lack of information on current farmers' knowledge, perception, and practices is a major constraint upon establishing an IPM programme (Morse and Bulher 1997; Van Mele 2000). This paper addresses the effects on local knowledge of applying on-farm research and it explores the potential contribution of other sources of knowledge, such as that of fruit-pickers, to promote more environmentally friendly practices. A survey was conducted in Benin, focusing on: (i) mango production constraints and (ii) local knowledge and practices by

*Corresponding author. Email: p.vanmele@cgiar.org

ISSN 0967-0874 print/ISSN 1366-5863 online

DOI: 10.1080/09670870802014940
http://www.informaworld.com

producers and pickers with regard to fruit flies and the weaver ant *O. longinoda*.

2. Materials and methods

In 2004, the International Institute of Tropical Agriculture (IITA) and the French Agricultural Research Centre for International Development (CIRAD) jointly established a research programme on mango fruit fly control in Benin. The project conducted on-farm research in Borgou department in the northern Guinea savanna, which accounts for 75% of mango production in Benin. Initial research focused on identification of mango fruit fly species, their monitoring, the use of different traps, attractants and bait sprays and the role of weaver ants. The 15 growers who took part in the on-farm research had relatively well-maintained orchards and were asked to refrain from using insecticides. They did not receive any financial compensation. In 2006, one of us (Van Mele) initiated a small project on weaver ants, which re-enforced the fruit fly project. In 2007, research results led to the establishment of a large, regional fruit fly project in West Africa with World Bank support. Both fruit fly projects were managed by another of us (Vayssières).

This study was conducted from March to May 2007. Four municipalities with differing environmental characteristics were selected in Borgou department, namely Bembèrèkè, N'dali, Parakou and Tchaourou. Primary data collection encompassed: group discussions (with farmers, key informants, and representatives of farmer organisations); individual interviews; field observations; and focus group discussion with rural women who harvest the fruit (pickers). The selection of farmers for individual interviews and participation to the group discussions was based on their willingness to participate. Apart from the 15 growers taking part in the on-farm research, 40 other growers, mostly having both mango and cashew plantations, were interviewed individually (Table 1). The 55 growers represented about 50% of all plantation owners in Borgou department. Harvesting is done by a seasonal labour force, comprising village women and children. Because they operate in groups, we interviewed about 90 pickers in five focus group discussions held in five villages during harvest time.

The methods and tools used for collecting information were based on procedures for analysing agricultural problems and assessing farmers' knowledge, perceptions and practices (KPP), as documented by Werner (1993), Pretty et al. (1995) and Chambers (1997). We used semi-structured interviews and open discussions in group settings to identify production constraints. About 145 farmers took part in various group discussions. Subsequently, farmers who volunteered were individually interviewed using open and semi-structured interviews, combined with field observations, in order to elicit their KPP in orchard pest management. Topics related to the farmers' ability to identify orchard pests and damages, their knowledge and practices on natural pest control, especially in relation to the use of weaver ants, and their sources of information. In addition, we collected farmers' socio-economic status, their experience in orchard production, and the characteristics of their orchard and surrounding environment. Secondary data were collected on the village social structures and other contextual facts through informal discussions.

Table 1. Localities and number of growers interviewed, Borgou department, northern Benin, 2007.

Municipality	Village	Number of farmers interviewed
Bembèrèkè	Danguinikou	8
	Ina	5
N'dali	Centre	12
	Tamarou	12
	Kakara	3
	Sirarou	8
Parakou	Centre	3
	Korobourou	2
Tchaourou	Tchachou	2
Total		55

Each interview lasted on average 1 h. Since the period of the survey coincided with the fruiting and harvesting season we were able to cross-check farmers' answers regarding pest status by visiting their fields and identifying the pest to which they ascribed the damage. Survey data were encoded and statistical analysis accomplished with parametric and non-parametric tests using SAS statistical software. Information on the procedures is given in the captions to the text and tables.

3. Results

3.1. Farmers' profile and production constraints

Few farmers interviewed were literate or had attended extension courses on pest management. More than 80% of the growers were older than 45 years, with the younger ones having inherited the orchard. All had established their orchard as a form of retirement insurance. Growers and pickers had more than 10 years of experience (Table 2). Selected growers for the on-farm research were often leaders of farmer organisations or religious organisations and appeared to be among the better-off farmers, having bigger orchards and generally enjoying a high status in the community. Project farmers were significantly more educated (Cramer's $V = 0.62$, $P < 0.001$) and more of them had attended extension courses than had non-project farmers (Cramer's $V = 0.33$, $P < 0.01$).

Table 2. Socio-economic profile and production constraints of mango and cashew farmers, northern Benin, 2007.

	% Farmers reporting			
	Project (n = 15)	Non-project (n = 40)	Pickers (n = 5 groups)[1]	Test[2]
Farmers' literacy rate	83	27	0	V = 0.62***
Exposure to extension courses	40	12	0	V = 0.33**
Experience in fruit production and harvesting (years) (mean ± SE)	21.4 ± 2.6	20.9 ± 1.5	14.0 ± 1.9	Var. NS
Production system				
S1	33	0	–	
S2	77	40	–	
S3	0	55	–	
Production constraints				
Pests	100	100	100	
Theft	80	50	40	
Bush fire	60	25	0	
Marketing	60	50	100	
Labour	40	25	60	
Post-harvest	13	20	100	
Economic damage caused by pest (%)				
<20	0	5	0	V = 0.09 NS
$20 \leq X < 45$	80	75	80	
≥ 45	20	20	20	

[1]One group discussion is considered as one interview and the answer considered is the consensus answer given by the group. [2]Tests conducted were t-test, one-way ANOVA (var) or Chi-squared with Cramer's V to indicate strength of relation. NS, not significant, *significant at 5% level, **significant at 1% level, ***significant at 0.1% level. [3]Others include workers, retired government officials, etc. S1: big orchard (>10 ha), selected cultivars only, use of input and modern equipment and permanent labour; S2: middle-sized orchard (2 < X < 10 ha), mixed cultivars (local and selected cultivars), input not necessarily used, equipment is hired, and occasional labour input; S3: small orchard (<2 ha), local cultivars only, no input, no equipment, and familial labour.

In the study area, all growers and pickers identified pest damage to the fruit as the main problem. Most growers estimated the economic damage caused by pests at between 20 and 45%. However, apart from the project farmers most growers did not manage pests. The former group only stopped spraying insecticides at the request of the fruit fly project, which started to provide alternative practices as technical assistance. Theft, difficulties in weeding (leading to an increased risk of bush fires) and marketing were also mentioned as production constraints. In Benin, the women fruit-pickers are responsible for the harvest, purchase and marketing of the fruit. For them, the principal constraints were marketing and the deterioration of the fruit quality when infested with fruit fly larvae.

3.2. *Knowledge on pest biology and damage*

The main pests perceived as causing damage were fruit flies, which was confirmed by field observation. A commonly used term in the local language Bariba was *kokonou* meaning worms, irrespective of the fruit attacked. S*onsou* or *sonou* refers to flies in general, with no specific name being given to fruit flies. In the local language Dendi, however, farmers call flies *hamni* and fruit flies *mango hamni*. Likewise, fruit fly larvae are called *mango nooni*.

In contrast to non-project farmers and women fruit-pickers, the majority of growers involved in the on-farm research knew about the relationship between fruit fly adults and larvae inside the fruit ($V = 0.44$, $P < 0.01$) (Table 3). Also, significant differences between categories occurred with regard to diagnosing fruit in which young larvae have started to develop, which takes place about 2–3 days post-oviposition ($V = 0.37$, $P < 0.05$). However, none of the growers or pickers interviewed were able to spot a freshly deposited fruit fly egg in a mango. When eggs are deposited under the skin, only a translucent drop appears, which, considering the height of the trees, is often difficult for the untrained eye to observe. None of the growers and pickers considered scale insects as insects; rather, they believed them to be *taches* or spots caused by ants (similar to fruit skin damage caused by deposits of formic acid).

3.3. *Knowledge and perception regarding weaver ants*

3.3.1. *Ant ecology and behaviour*

Farmers called the weaver ant *tantanpouro* and *coco-mbissi* in the local languages Bariba and Dendi, respectively. The weaver ant is considered to be an ant that rolls up tree leaves, protects against pests, but also damages fruit by making spots and hindering harvest operations. The extent to which each of these contributes to farmers' overall perception is discussed below. The majority of growers and pickers reported that mango trees, especially local varieties, are the trees most preferred by *Oecophylla* because of their dense foliage, leaf characteristics and 'perfume' (Table 4).

Farmers perceived the rainy season to be the best time for ants to make nests, as trees produce new growth flushes, food (insects) is abundant, and the weather is cool. The on-farm research apparently had a positive effect on farmers' observational capacities: 80% of the growers involved in the project had observed the predatory action of the ant and believed that most predation took place during the rainy season, whereas only 20% of non-project farmers and fruit-pickers had ever observed its predatory activity.

3.3.2. *Weaver ants: pest or natural enemy?*

The ants' role in protecting orchards against thieves appeared to be common knowledge. Apart from this, farmers' overall perception of the weaver ant differed significantly between categories ($V = 0.44$, $P < 0.001$) (Table 5). About 80% of project farmers and all women fruit-pickers reported the protective nature of *Oecophylla* against pests, compared to only 25% of non-project farmers. According to those farmers appreciating the presence of *Oecophylla*, ants improve the mango quality and yield by reducing the amount of rotten fruit, extending the mango shelf life, giving the fruit a healthy appearance and improving its juice quality, especially its sugar content. In contrast, non-project farmers (75%) were concerned about the negative effect of ants on fruit due to the small black spots, which they believe to degrade

Table 3. Farmers knowledge of orchard pest biology and diagnosis, northern Benin 2007.

	% Farmers reporting			
Elements of pest biology	Project ($n = 15$)	Non-project ($n = 40$)	Pickers ($n = 5$ groups)[1]	Test[2]
Relate adult flies and larvae	73	25	20	$V = 0.44$**
Recognise fruit fly damage (within 1–2 days after oviposition)	0	0	0	NS
Recognise fruit fly damage (>2 days after oviposition)	100	68	100	V = 0.37*
Distinguish between scales and formic acid spots	0	0	0	NS

[1]One group discussion is considered as one interview and the answer considered is the consensus answer given by the group. [2]Test conducted was Chi-squared with Cramer's *V* to indicate strength of relation. NS, not significant, *significant at 5% level, **significant at 1% level, ***significant at 0.1% level.

Table 4. Farmers' knowledge of weaver ant ecology and behaviour, northern Benin 2007.

	% Farmers reporting		
Ant ecology and behaviour	Project ($n = 15$)	Non-project ($n = 40$)	Pickers ($n = 5$ groups)[1]
Preferred tree species	Mango (100)	Mango (100)	Mango (100)
Preferred mango cultivars	Local cultivars (73) Foliage cultivars (40)	Local cultivars (75) Foliage cultivars (20)	Local cultivars (100)
Reasons	A lot of foliage Sweet fruit Perfume of the variety	A lot of foliage Sweet fruit Perfume of the variety	A lot of foliage Sweet fruit Perfume of the variety Waxy leaves Large leaves
Abundance period of ant	Rainy season (86)	Rainy season (75)	Rainy season (100)
Reasons	Growth of new leaves Cool weather More food (insects)	Growth of new leaves Cool weather More food (insects)	Growth of new leaves Cool weather More food (insects)
Observation of predation	(80)	(20)	(20)
Period of abundant predation	Rainy season	Rainy season	Rainy season
Type of prey	Insect larvae Insect adult	Insect larvae Insect adult	Insect larvae Insect adult Weaver ant

[1]One group discussion is considered as one interview and the answer considered is the consensus answer given by the group.

Table 5. Percentage of farmers reporting on weaver ant status, northern Benin 2007.

Ant status	% Farmers reporting Project ($n=15$)	Non-project ($n=40$)	Pickers ($n=5$ groups)[1]	Test[3]
Positive action of ant				
Protection against theft	100	100	100	NS
Protection against pest	87	25	100	$V = 0.61$***
Fruit quality improvement[2]	20	10	60	$V = 0.36$**
Negative action of ant				
Disrupt harvest operations	100	100	100	NS
Damage fruit with spots	33	62	20	$V = 0.31$*
Global status of ant				
Ants are beneficial	80	25	60	$V = 0.48$***
Ants are a pest	20	75	40	

Respondents had no idea about the topic. [1]One group discussion is considered as one interview and the answer considered is the consensus answer given by the group. [2]Quality includes shelf life, sweetness of juice and overall healthy appearance. [3]Test conducted was Chi-squared with Cramer's *V* to indicate strength of relation, NS, not significant, *significant at 5% level, **significant at 1% level, ***significant at 0.1% level.

the fruit. None of the farmers was able to explain why and how the weaver ants make black spots.

3.3.3. Techniques for avoiding ant bites

Farmers reported only a few techniques for avoiding ant bites during harvest. Commonly, a long picking pole is used. However, this technique has the inconvenience that the fruits fall down on the ground with some becoming unsuitable for consumption. Very few farmers cited other techniques such as climbing the trees to pick the fruit at the hottest 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.

4. Discussion

The majority of growers interviewed in Benin perceived 20–45% of their production to be lost due to fruit flies, with one fifth reporting even higher losses. In fact, since the recent invasion of the new fruit fly species, *Bactrocera invadens*, economic damage caused by fruit flies in Benin exceeded 60% in the second half of the mango season (Vayssières et al. 2006). Cultural, economical and structural reasons underlie the lack of appropriate pest management: (i) in developing countries, fruit trees are rarely monitored for pests and pest management is hampered by tall tree size and insufficient farmer knowledge; (ii) if available, the control methods are too expensive, and (iii) fruit-growers have been neglected by extension services (Van Mele 2000).

Many control methods are being tested in growers' orchards in Benin under the ongoing fruit fly project. Those involved in the on-farm research refrained from using insecticides to control fruit flies. However, this behaviour may be abandoned after the project ends, especially since the high-technology innovations, such as baits and fruit fly traps provided by the project, are not available on the market. The extent to which growers learned to appreciate the benefits of the endemic natural enemy *Oecophylla* may, by and large, influence whether these farmers will start using insecticides again.

Taking the context of fruit tree pest management into account, appropriate pest management options should be cost-effective, locally available, self-established, reproducible and sustainable. Use of weaver ants is a particularly suitable option. Being generalist predators, the ants patrol trees continuously seeking prey. Abundant populations of the weaver ant *Oecophylla* control fruit flies effectively (Van Mele et al. 2007). However, African farmers, extension staff and scientists often have a negative attitude towards weaver ants and are unaware of their beneficial effects. Appropriate rural education based on discovery learning and action research could help all participants to acquire basic skills in diagnosing early fruit fly damage and developing confidence in the effectiveness of weaver ants as a pest control agent.

Scientific validation of local knowledge by scientists may increase farmers' pride in their use (Thrupp 1989) and also help to define which farmers could be integrated as experts in future collaborative development of alternative strategies (Van Mele and Cuc 2000). However, in doing so scientists often focused on farmers only, neglecting other crucial sources of local knowledge. By interviewing fruit-pickers we learnt that they have accumulated through their own experience some knowledge on fruit fly damage, appreciated other benefits of weaver ants and learnt how to reduce their nuisance during harvest. 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 fruit-growers and fruit-pickers. The weaver ant *Oecophylla* is easy to observe. Even though observations of its predatory behaviour are influenced by tree size, at least its nests are conspicuous, and tree pickers tend to spend more time in the tree canopy than growers, which gives pickers an advantage for observing ants. Also, the cultural importance of weaver ants is different for fruit-growers, who consider *Oecophylla* to be mainly a *gendarme* or police that protects their orchards from thieves. Women fruit-pickers in Benin, however, directly negotiate the price of their harvest with the grower after which they try to sell the fruit at the local market. Since not all mangoes are sold immediately, fruit quality and shelf life determine the difference between loss and profit. Through experience most women have learnt that orchards with weaver ants yield better fruit. Future development interventions could stimulate sustainable production systems, in which *Oecophylla* plays a key role, by strengthening the demand side and attributing a stronger role to fruit-pickers in farmer-training programmes. For example, respected fruit-pickers could be taped on video, explaining their observations of weaver ants.

Acknowledgements

We thank the anonymous reviewers for their constructive comments, and are indebted to all the growers and fruit-pickers involved in the research. This work was sponsored by the French Cooperation and the Conservation, Food and Health Foundation. The Africa Rice Center (WARDA), the International Institute of Tropical Agriculture (IITA) and the French Agricultural Research Centre for International Development (CIRAD) supported this study.

References

Bentley J, Rodriguez G. 2001. Honduran folk entomology. Curr Anthropol. 42:285–301.

Chambers R. 1997. Whose reality counts? Putting the first last. London: Intermediate Technology. p. 297.

Lux SA, Ekesi S, Dimbi S, Mohamed S, Billah M. 2003. Mango-infesting fruit flies in Africa: Perspectives and limitations of biological approaches to their management. In: Neuenschwander P, Borgemeister C, Langewald J, editors. Biological control in IPM systems in Africa. Wallingford (UK): CABI Publishing. p. 277–294.

Morse S, Buhler W. 1997. IPM in developing countries: The danger of an ideal. Integ Pest Man Rev. 2:175–185.

Peng RK, Christian K, Gibb G. 1997. Distribution of the green ant, *Oecophylla smaragdina* (F.) (Hymenoptera: Formicidae), in relation to native vegetation and the insect pests in cashew plantations in Australia. Int J Pest Man. 43(3):203–211.

Pretty JN, Guijt I, Scoones I, Thompson J. 1995. Participatory learning and action: A trainers' guide. London: International Institute for Environment and Development. p. 249.

Thrupp LA. 1989. Legitimizing local knowledge: From displacement to empowerment for third world people. Agric Human Values. 6(3):13–24.

van Huis A, Meerman F. 1997. Can we make IPM work for resource-poor farmers in sub-Saharan Africa? Int J Pest Man. 43(4):313–320.

Van Mele P. 2000. Evaluating farmers' knowledge, perceptions and practices: A case study of pest management by fruit farmers in Mekong Delta. Vietnam [PhD thesis]. Wageningen University, The Netherlands, 225 p.

Van Mele P. 2008. A historical review of research on the weaver ant *Oecophylla* in biological control. Agric For Entomol. 10(1):13–22.

Van Mele P, Chien HV. 2004. Farmers, biodiversity and plant protection: Developing a learning environment for sustainable tree cropping systems. Int J Agri Sustainabil. 2(1):67–76.

Van Mele P, Cuc NTT. 2000. Evolution and status of *Oecophylla smaragdina* (Fabricius) as a pest control agent in citrus in the Mekong Delta, Vietnam. Int J Pest Man. 46(4):295–301.

Van Mele P, Vayssières J-F, van Tellingen E, Vrolijks J. 2007. Effects of the African weaver ant *Oecophylla longinoda* in controlling mango fruit flies (Diptera: Tephritidae) in Benin. J Econ Entomol. 100(3):695–701.

Vayssières J-F, Sanogo F, Nousourou M. 2004. Inventaire des espèces de mouches des fruits (Diptera: Tephritidae) inféodées au manguier au mali et essais de lutte raisonnée. Fruits. 59(1):3–16.

Vayssières J-F, Goergen G, Lokossou O, Dossa P, Akponon C. 2005. A new *Bactrocera* species in Benin among mango fruit fly (Diptera: Tephritidae) species. Fruits. 60(6):371–377.

Vayssières J-F, Lokossou O, Ayégnon D, Bouéyi S, Akponon C. 2006. Inventaire, fluctuations des populations et importance des dégâts des espèces de mouches des fruits (Diptera: Tephritidae) inféodées au manguier dans le département du Borgou (Bénin) en 2005 et 2006. Atelier Scientifique National de l'INRAB. 19–22 Décembre. Abomey Calavi. Cotonou. Bénin, p. 8.

Werner J. 1993. Participatory development of agricultural innovations: Procedure and methods of on-farm research. Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit. p. 251.