Farmers' Experiences on the Blue Gum Chalcid, *Leptocybe invasa*, Infestation on *Eucalyptus* Species in East Africa

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Abstract

Understanding indigenous knowledge and practices is important in facilitating the development and introduction of pest management technologies that meet farmers' aspirations and are, thus, likely to be adopted by them. This paper documents farmers' knowledge, perceptions and control practices of a gall-forming wasp, *Leptocybe invasa* Fisher & LaSalle, in Uganda and Kenya with the aim of developing integrated management of the pest. Although the vast majority of farmers interviewed had observed the symptoms of *L. invasa* infestation on *Eucalyptus*, very few of them were aware of the causative agent. They reported the infestation as causing reduced growth rate, deformation and mortality of *Eucalyptus*. However most farmers did not attempt to control the infestation because they did not know suitable control methods and/or the cause. Only 19% of farmers in Uganda and 26% in Kenya had received advice on *L. invasa*. Even after observing severe *L. invasa* infestation, most farmers interviewed still wanted to plant *Eucalyptus*, which most of them considered as an important source of income, firewood and construction materials. As plantation forestry are developed and promoted, there is a need to integrate farmers' knowledge about tree pests into the development processes in order to improve their pest management practices.

Key words: Eucalyptus, indigenous knowledge, *Leptocybe invasa*, pest management

Résumé:

La compréhension des connaissances et des pratiques indigènes est importante pour permettre le développement et l'introduction des technologies de gestion des parasites, qui répondent aux aspirations des paysans et qui peuvent être facilement adoptées par ces derniers. Cet article fait état des connaissances indigènes, de leur perceptions et pratiques en matière de lutte contre *Leptocybe invasa* Fisher & de LaSalle, une espèce de guêpe qui cause des nodules à l'eucalyptus en Ouganda et au Kenya, dans le but de développer une gestion intégrée de ce ravageur. Bien que la grande majorité de paysans demandés aient observé les symptômes de dégâts de *L. invasa* sur l'eucalyptus, très peu d'entre eux n'en connaissaient pas l'agent causal. Ils savent que l'infestation cause une réduction de la croissance, la déformation et la mortalité l'eucalyptus. Cependant, la plupart des paysans n'ont pas essayé de contrôler les dégâts parce qu'ils n'étaient pas au courant des méthodes appropriées de lutte et/ou la cause. Seulement 19% de paysans en Ouganda et 26% au Kenya avaient reçu des informations et conseils sur *L. invasa*. Même après avoir observé les dégâts graves de *L. invasa*., la plupart des paysans interrogés veulent toujours planter l'eucalyptus que la majorité d'entre eux considèrent comme une source importante de revenus, de bois de chauffage et des matériaux de construction. Puisque les plantations sylvicoles se développent et sont encouragés, il est nécessaire d'intégrer les connaissances paysannes sur des parasites d'arbres dans les procédures de développement, afin d'améliorer leur façon de gérer des parasites.

Mots-clés : Eucalyptus, connaissance indigène, *Leptocybe invasa*, gestion de parasite

Introduction

Eucalyptus species are the most widely planted exotics in the tropics with several species grown in large plantations in over 80 countries (Wylie and Floyd, 1998). In East Africa, *Eucalyptus* species have been planted for about a century now. Many projects and government institutions in East Africa promote the planting of *Eucalyptus*. For example, the Kenya Forestry Research Institute (KEFRI) and the Uganda Forestry Resources Research Institute (FORRI) recently imported a number of *Eucalyptus* clones from South Africa, which are under trials in several ecological zones in these countries. The Uganda National Forestry Authority is promoting planting of *Eucalyptus* as one of the key species for private commercial plantations in Uganda. In addition, private companies such as the British American Tobacco (BAT) encourage the

establishment of *Eucalyptus* woodlots as an alternative supply of timber and fuelwood. It has been estimated that in Kenya, the Forest Department alone manages about 15,000 ha of *Eucalyptus*, and the private sector about 35,000 ha (ISAAA, 1995). In Uganda, by the year 2001, the Forest Department had established 3,822 ha of peri-urban *Eucalyptus* plantations (Esegu, *et al.*, 2001), and it is now estimated that over 40,000 ha of *Eucalyptus* has been planted by various agencies, including sugar, tea and tobacco estates, tree planting groups and individuals in the country (Esegu, Pers. Com.).

Although *Eucalyptus* species generally have largely been free of major pest infestations in exotic plantations, except termites, there is increasing evidence of devastating pest problems on the species in several tropical countries (Nair, 2001). Recently, an alien gall-inducing wasp of Australian origin, *Leptocybe invasa* (Hymenoptera: Eulophidae), was reported to cause severe damage to *Eucalyptus* species in several countries including Algeria, Iran, Israel, Italy, Jordan, Kenya, Morocco, Spain, Syria, Turkey and Uganda (Mendel *et al.*, 2004). This has raised serious concerns among farmers, government departments and private agencies growing the species in Uganda and Kenya (Nyeko, 2004; Mutitu, 2003). The wide geographical distribution of the *L. invasa* observed in the last few years, suggests that the pest is fast spreading. Such pest infestations can severely constrain tree-planting efforts, and thus require development of sustainable management strategies.

One of the key issues that should be considered in developing sustainable pest management strategies is indigenous knowledge systems (Norton *et al.*, 1999). In particular, understanding farmers' knowledge and management of pest problems is important for the development and introduction of management strategies that meet farmers' aspirations and are thus likely to be adopted by them (Nyeko *et al.*, 2002). Unfortunately, there is a dearth of information on farmers' experiences on insect pests in forestry not only in East Africa, but also in most tropical countries. This paper documents farmers' awareness, perceptions and management of *L. invasa* in Kenya and Uganda.

Materials and Methods

The study was conducted in five districts of western Kenya (Bungoma, Busia, Nyando, Nandi and Vihiga) and eight in Uganda (Arua, Isingiro, Kumi, Masindi, Mbale, Ntungamo, Sironko and Tororo) from December 2005 to February 2006. The Kenyan districts were located in two agro-ecological zones (zones 2 and 3). The mean annual rainfall in these zones range from 1201-1600 mm, and the mean annual temperature varies from 10-25 °C in zone 2 and 15-30 °C in zone 3. The districts selected in Uganda were in five agro-ecological zones namely; Eastern, Eastern highlands, Lake Albert crescent, Southern drylands and West Nile). The rainfall pattern in these zones is bimodal with mean annual rainfall ranging from 1400-2500 mm. Mean annual temperature in the zones varies from 15-30 °C. Agriculture in the selected districts in both Kenya and Uganda is predominantly subsistent.

The districts were selected for the study because of severe *L. invasa* infestation reported in them (Mutitu, 2003; Nyeko, 2004). In this, we tried to maximise the probability of selecting farmers with some experiences on the pest. In each district, farmers who had planted at least 100 *Eucalyptus* trees were selected randomly from lists of *Eucalyptus* farmers that were obtained from FORRI, KEFRI or private agencies promoting *Eucalyptus* growing. A total of 100 and 59 respondents were interviewed using a pre-tested questionnaire in Kenya and Uganda respectively. These sample sizes were considered adequate as there was very little variability in farmers' responses within and between the countries.

The interviews were conducted in the farmers' local languages, and their responses carefully translated and recorded in English. To achieve this, research assistants who were fluent in both English and the local language in the different districts were recruited and trained to translate the questionnaire to the farmers, and the farmers' responses to the principal researcher in each country. Most survey questions were open ended in order to avoid limiting farmers' opinions. Data were collected on farmers' social and educational profiles as well as on their experiences in cultivation of *Eucalyptus*. Special emphasis was placed on exploring farmers' awareness of *Leptocybe invasa* and its infestation and their management practices against it. When asking for farmers' awareness of *L. invasa* infestation, each farmer was shown a fresh sample of *Eucalyptus* that was severely infested by the pest. This was done to ensure that the farmers clearly understood the *L. invasa* infestation for which they were being interviewed. Finally, farmers were asked about their future plans on cultivating *Eucalyptus* in order to understand the impotance of *Eucalyptus* in farmers' livelihoods. All interviews were conducted in farmers' *Eucalyptus* stands. This enabled researchers to cross-check farmers' answers regarding the pest status with field observations. Descriptive statistics in SPSS statistical package (release 10 for windows) was used to summarise the data into numbers and percentage of total respondents and/or responses.

Results

Farmers' Background

Over 90% of the respondents were from male-headed households, and the majority of them were married (Table 1). Nearly all respondents in both Uganda and Kenya had some formal education although the majority of them were only educated to primary and lower secondary levels. Whereas 9% of the respondents in Kenya were educated to university level, no respondent in Uganda was a university graduate (Table 1). The majority of farmers in both Uganda (56%) and Kenya (62%) inherited their land for planting *Eucalyptus*. A few farmers in Uganda cultivated *Eucalyptus* on land offered freely to them by the Ugandan government (2% of the respondents), schools (3%) and a church (2%). No farmer reported such free land offer in Kenya. Whereas the majority (70%) of *Eucalyptus* plantation/woodlot owners in Uganda were on farm full time, most (55%) of those interviewed in Kenya were part-timers on their farms.

Table 1: Background of farmers.

Variable	% of total respondents	
	Uganda	Kenya
Gender		
Male headed households	92	91
Female headed households	8	9
Marital status		
Married	93	94
Single	3	6
Widowed	3	0
Formal education		
None	3	2
Primary	41	37
Lower secondary	25	38
Upper secondary	3	6
Post secondary diploma/certificate	27	8
University	0	9
Land tenure		
Inherited	56	62
Purchased	36	36
Partially inherited and purchased	0	2
Free offer	9	0

Total respondents interviewed in Uganda and Kenya were 59 and 100, respectively.

Cultivation of Eucalyptus

Most farmers (73% of total respondents in Uganda and 66% in Kenya) established their *Eucalyptus* stands using the *"taungya"* system. Other planting methods reported by farmers were grassland planting (24% in Uganda and 31% in Kenya) and boundary planting mentioned only by some (2%) respondents in Kenya. Two farmers in Uganda had established their *Eucalyptus* stand using both *"taungya"* and grassland planting. Up to 61% and 54% of the farmers interviewed in Uganda and Kenya, respectively, had planted more than 1000 *Eucalyptus* trees on their farm. The other farmers had either planted between 100-500 trees (24% in both Kenya and Uganda) or 500 -1000 tree (15% in Uganda and 22% in Kenya). The most commonly planted *Eucalyptus* species in Uganda was *Eucalyptus grandis* Hill Ex Maid., planted by 78% of total respondents, followed by *E. camaldulensis* Dehnh. (29%), *E. saligna* Smith (14%) and *E. robusta* Smith (2%). In Kenya, the farmers had planted *E. grandis, E. saligna, E. camaldulensis* and *E. regnans*.

When asked to rate the mortality of their *Eucalyptus* in the previous year, 48% of the respondents in Uganda ranked the mortality as low (less than 20% of trees dead), 25% moderate (20-50% trees dead), 20% high (More than 50% of trees dead) and 7% reported no dead trees. Similarly, most Kenyan farmers (65%) ranked the mortality of their *Eucalyptus* in the previous year as low, 25% reported it as moderate, 8% high and 2% did not observe any dead trees. Farmers cited a number of mortality factors, the most commonly mentioned in both countries being termites, drought and unspecified diseases. Less commonly reported causes of *Eucalyptus* mortality were fire and livestock, mentioned in both Uganda and Kenya, and late tending, *L. invasa*, water logging, a beetle species and vandals mentioned only in Uganda. A few farmers (3 in Uganda and 10 in Kenya) did not know the cause of the tree death they had observed.

Experiences on Leptocybe invasa Infestation

Up to 100% and 94% of the farmers interviewed in Uganda and Kenya, respectively, had observed *L. invasa* infestation on *Eucalyptus*. However, very few of them (7% in Uganda and 12% in Kenya) claimed to be aware of the causative agent. These farmers attributed the infestation to unidentified small insects and disease, ants, or bad planting materials. All farmers first observed *L. invasa* infestation on *Eucalyptus* species between the years 2000 to 2005, except two from Uganda who claimed to have first seen the problem in 1997. The majority of farmers (60% in Uganda and 74% in Kenya) reported *L. invasa* infestation to be most common in the dry season. Some respondents perceived the infestation to be most common in wet season (3% in Uganda and 11% in Kenya) or equal throughout the year (25% in Uganda and 5% in Kenya). A few others (15% in Uganda and

9% in Kenya) were not sure of the seasonal variation in the incidence of *L. invasa* infestation.

The majority of farmers in both Uganda and Kenya ranked the incidence of *L. invasa* infestation on less than one-year old *Eucalyptus* seedlings or coppices as high (Table 2). In contrast, most farmers reported low or no *L. invasa* infestations on *Eucalyptus* stands older than three years. When asked to mention the effects of *L. invasa* infestation on *Eucalyptus*, the majority of the farmers (60% in Uganda and 53% in Kenya) reported that the insect reduces the growth rate of *Eucalyptus*. Some farmers cited reduced growth (25% in Uganda and 38% in Kenya) and tree mortality (15% in Uganda and 8% in Kenya). A few farmers (1% in Uganda and 2% in Kenya) were not sure of the effect of *L. invasa* on *Eucalyptus*, suggesting their limited experience with the pest.

Table 2: Farmers' ranking of *Leptocybe invasa* damage on different growth stages of *Eucalyptus* Species

Growth stage	Damage level (number of responses)*				Total responses	
	None	Low	Moderate	High	No.	%
Uganda						
1 year old	O	5	8	35	48	39.7
1-3 years old	16	17	9	9	51	42.1
3-5 years old	12	4	1	2	19	15.7
> 5 years old	2	1	0	0	3	2.5
Kenya						
1 year old	2	14	26	53	95	29.8
1-3 years old	16	26	48	5	85	26.6
3-5 years old	17	45	10	4	76	23.8
> 5 years old	38	18	4	3	63	19.7

None refers to no tree infested by *L. inverse*; low, less than 25% of trees in stand infested by *L. invasa*; moderate, 25-50% of trees infested; high, more than 50% of trees infested.

Some farmers (48% in Uganda and 17% in Kenya) claimed that they had observed *L. invasa* infestations on other tree species and/or crops (Table 3). Up to 13 and 5 species were perceived to be infested by *L. invasa* in Uganda and Kenya, respectively. Cassava was by far the most commonly mentioned species in both Kenya and Uganda (Table 3). However, when farmers presented samples of the plants they perceived were infested by *L. invasa* to the researchers, no typical *L. invasa* gall damage on any of the samples was observed, indicating that farmers had misdiagnosed the infestations.

Table 3: Farmers' observations of *Leptocybe invasa* infestation on plants other than *Eucalyptus* species

Tree/crop species	Responses			
	Uganda		Kenya	
	No.	%	No.	%
Manihot esculenta Grantz (cassava)	18	47.4	9	52.2
Citrius species (oranges)	5	13.2	0	0.0
Mangifera indica L. (mangoes)	3	7.9	0	0.0
Musa species (banana)	2	5.3	0	0.0
Spathodea campanulata Beauv.	2	5.3	0	0.0
Thevolia species	1	2.6	0	0.0
Persea americana Mill. (avocado)	1	2.6	0	0.0
Markhamia lutea (Benth.) K.Schum.	1	2.6	0	0.0
Phaseolus vulgaris L. (beans)	1	2.6	0	0.0
Coffea species (coffee)	1	2.6	0	0.0
Arachis hypogaea L. (groundnuts)	1	2.6	0	0.0
Zea mays L. (Maize)	1	2.6	1	5.9
Annona senegalensis Pers.	1	2.6	0	0.0
Cupressus lusitanica Mill.	0	0.0	5	29.4
Lantana camara L.	0	0	1	5.9
Gossypium hirsutum L. (cotton)	0	0.0	1	5.9
Total	38	100.0	17	100.0

Control of Leptocybe invasa

Very few farmers (20% in Uganda and 28% in Kenya) had attempted to control *L. invasa*. Most farmers who had not attempted to control the pest mentioned several reasons, the most common being lack of knowledge for appropriate control measures (Table 4). Farmers who attempted to control *L. invasa* used cultural, physical or chemical methods. The cultural and physical methods included dusting ash on leaves, weeding, pruning and uprooting infested seedlings. The chemicals farmers had applied to control *L. invasa* included Sumithion (fenitrothion), Marathon (imidacloprid), malathion, Fenkil, diamethoate and Ambush (permethrin). Of these, Sumithion, Malathion and Ambush were reported to be ineffective while Fenkil and diamethoate were reported as being highly effective against the pest.

Table 4: Farmers' reasons for not controlling *Leptocybe invasa*

Reasons	Response			
	Uganda		Kenya	
	No.	%	No.	%
Lack of knowledge on control measures	35	64.8	65	87.8
Cause unknown	12	22.2	4	5.4
Lack of money	5	9.3	4	5.4
Lack of interest	1	1.9	1	1.4
Not given it a serious thought	1	1.9	0	0.0
Total	54	100.0	74	100.0

The majority of farmers (81% in Uganda and 74% in Kenya) had not received any advice on managing the *L. invasa*. The few farmers who received some advice cited various sources including FORRI, NFA, KEFRI, district forest and agricultural departments, farmers associations, forestry colleges or neighbours. Generally, the advice given to farmers included preventive (plant resistant types of *Eucalyptus*), cultural (plant healthy seedlings, weed properly, ensure timely planting), chemical (spray infested trees with insecticides) and mechanical (cut and burn infested trees) measures. Some three farmers in Uganda were advised to wait because control measure against the pest was still being sought.

Future plans on Eucalyptus planting

The majority of farmers in Uganda (95%) and Kenya (90%) still wanted to plant *Eucalyptus* species in spite of the problems they had encountered in cultivating the species. They cited a number of reasons for taking this decision (Table 6). In both Kenya and Uganda, most farmers considered *Eucalyptus* to be important sources for income, construction materials and fuelwood. Ugandan farmers commonly mentioned their own stands or nurseries (39% of total respondents) and open markets (37%) as sources of their planting materials (seeds and/or seedlings) for future planting.

Table 5: Reasons for farmers' interest in growing more *Eucalyptus* in future.

Reasons	Response			
	Uganda		Kenya	
	No.	%	No.	%
Income	50	30.9	75	35.0
Supply of construction materials	47	29.0	42	19.6
Fuelwood	46	28.4	39	18.2
Environmental protection	9	5.6	12	5.6
Boundary marking	4	2.5	24	11.2
Bee forage	2	1.2	0	0.0
Fast growth	1	0.6	12	5.6
Coppices very well	1	0.6	0	0.0
Less labour demanding	1	0.6	0	0.0
Land available	1	0.6	0	0.0
Others**	0	0.0	10	4.7
Total	162	100.0	214	100.0

* Numbers do not add up because of possible multiple responses.

** Draining water, for donation to neighbours and/or ornamental.

In Kenya, 27% of the farmers had planned to obtain planting materials from their own farms and 25% from non-governmental organisations and community-based organisations. Other sources of planting materials farmers mentioned included FORRI and NFA (in Uganda only), KEFRI (in Kenya only), forest departments and private companies such as the British American Tobacco. The few farmers who were not interested in planting more *Eucalyptus* mentioned various reasons including land shortage, *L. invasa* infestation, and lack of capital and ready market for *Eucalyptus* products.

Discussion

This study has demonstrated that *Eucalyptus* growers in both Uganda and Kenya are concerned about pest and disease problems on their trees, suggesting that they would be receptive to innovative control measures. Research and extension efforts are necessary to generate and/or transfer information on the management of pests and diseases that farmers consider important to them. Other constraints cited by farmers should not be overlooked. For example a lack of technical advice indicates the need to review and strengthen forestry extension systems. A lack of quality planting materials requires education of farmers in seed production and harvesting, as well as in good nursery practices so that they can raise healthy seedlings. For example, the effects of prolonged dry spells may be minimised by early planting of seedlings or seeds. This requires proper timing of seed sowing in nurseries to match the onset of the long rainy season (Nyeko and Olubayo, 2005).

The high level of awareness about *Leptocybe invasa* infestation on *Eucalyptus* among farmers confirms earlier reports that the insect was causing widespread infestation in Uganda and Western Kenya (Nyeko, 2004; Mutitu, 2003) Farmers' awareness of the gall damage was apparently attributed to the conspicuous and severe symptoms of the pest infestation rather than their knowledge of the pest. Indeed, the majority of them were not only unaware that *L. invasa* was the cause of the damage on their *Eucalyptus*, but also reported not knowing the insect. This may be attributed to the small size of the insect (Mendel *et al.*, 2004) and/or farmers' short experience with the pest infestation. This may explain their misdiagnosis of the infestation on other tree species and crops. Findings from other studies indicate that, farmers have good ecological understanding of those pests that can easily be observed, but they ignore or tend to underestimate those pests that are difficult to observe (Abate *et al.*, 2000; Van Mele and Van Chien, 2004; Nyeko *et al.*, 2002) or those whose effects are difficult to interpret (Van Mele *et al.*, 2001). Farmers need to be educated on some basic biology and ecology of *L. invasa*

(identification, mode of infestation and population dynamics in relation to seasonal changes, etc.) so that they can make informed decisions on the pest.

Despite the high level of *L. invasa* damage, most farmers did not attempt any control, and the control methods reported here may have limited impact. The use of insecticides may not only have short-term effects on the pest, but may pose economic, social and health concerns (Repetto and Baliga, 1996). Insecticides may best be suited for controlling *L. invasa* in nurseries, to ensure good quality seedlings suitable for field planting. Pruning and removal of infested trees are also potential control methods, but tend to be labour intensive. Also, the methods kill only insects that are enclosed in the galls during the time of the operations. Farmers suggested the use of resistant tree species, but greater work is needed to identify resistant *Eucalyptus* germplasms. None of the farmers reported natural enemies as a means to reduce *L. invasa* infestation. Similarly, there is apparently no published information on the natural enemies of *L. invasa* despite the importance of biological pest control in forestry. Several kinds of wasps parasitise gall-forming insects and limit the number of galls formed (Walsh, 1996), and should therefore be protected. Adult gall-forming insects leave galls through exit holes. The vacated space is often occupied by small spiders and beneficial insects such as lacewing larvae, ants or parasitic wasps (Walsh, 1996; Drees, 1999). The use of such natural enemies for controlling *L. invasa* should be investigated and promoted, where feasible.

Even after observing severe *L. invasa* infestation, nearly all farmers interviewed still wanted to plant *Eucalyptus*, and they saw the trees as a source of several products and services, especially income generation, firewood and construction materials. This suggests that the various uses of *Eucalyptus* were farmers' considerations for taking known risks. However, the fact that the majority of them were inclined to obtain planting materials from their own stands or nurseries and from open markets shows that they will continue to plant the *L. invasa* susceptible species such as *Eucalyptus grandis* and *E. camaldulensis*, which were popularly grown. Clearly this indicates the need for urgent development and/or transfer to farmers of information on management strategies against the pest.

Conclusions and recommendations

This study has provided some knowledge on farmers' understanding of the *L. invasa* problem on *Eucalyptus*. Attempts to develop management strategies for the pest should build on the positive attributes by expanding on the knowladge and range of options available to farmers. Generation, synthesis and transfer of information about the pest among researchers, extension agents, policy makers, tree growers, suppliers of forestry supplements, and private agencies is urgently necessary to speed up successful development and implementation of sustainable management strategies against the pest.

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