# Coping strategies employed by farmers against the larger grain borer in east Africa: Preliminary observation

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*Abstract*

The Larger Grain Borer, *Prostephanus truncatus* (Horn), has been established in East Africa for more than 15 years. During that time, recommendations have been introduced to enable farmers to combat this most destructive pest of stored maize and dried cassava. The initial control method introduced was that to shell maize, treat it with an insecticidal mixture and store it in a suitable container. This procedure represented a major change for families who traditionally stored maize on the cob. Subsequently, other methods have been tried including spraying cobs with insecticide and the release of a biological control agent (in Kenya), Teretriosoma nigrescens, a histerid insect Other than an evaluation of the rate of uptake of recommendations there has not been any assessment of the efficacy of treatments used to protect grain against LGB nor the extent to which farmers are coping with this pest.

Surveys were conducted in six regions throughout LGB-infested areas in Tanzania: Arusha, Iringa, Kilimanjaro, Morogoro, Rukwa and Tabora to determine the extent of the pest problem, the strategies farmers are using to overcome it and the constraints they face In each region, four villages were visited and 20 farmers were interviewed individually. In these villages, group discussions were held to put the LGB and other storage problems into a general agricultural perspective and to compare the current situation to that which occurred when the pest was first introduced. The survey indicates that, in general, production, storage and marketing outcomes have not been influenced much by LGB. This is not because LGB is regarded as a minor problem, on the contrary, farmers regard it as the most important storage related problem in each of the six regions. The key point brought out by the survey is that farmers are, on the whole, taking measures that control the pest effectively. The use of Actellic is widespread: it is applied by over 70% of surveyed farmers in each region. Most of these are using Actellic Super Dust, with the exception of Morogoro where many farmers prefer to spray Actellic EC onto their grain. On the whole, farmers find the use of ASD/Actellic EC to be effective against LGB. It was only in Kilimanjaro that a sizeable minority of farmers (20%) felt that ASD was not effective against LGB, this is probably due to adulteration. In addition, there have been significant changes in ASD was not effective against LGB, this is probably due to adulteration. In addition, there have been significant changes in storage structures. Many more farmers are now shelling their maize and storing it in sacks, whereas 15 years ago storage on the cob in crib was commonplace.

## Introduction

The Larger Grain Borer (LGB), *Prostephanus truncates* (Horn) was first reported as a pest in Africa nearly 20 years ago (Dunstan and Magazini, 1981). Since then, the beetle has spread throughout both East and West Africa, its current distribution is shown in Figure 1.

*P. truncatus* is a major pest of stored maize, the primary food staple of most of sub-Saharan Africa. The beetle is able to develop and reproduce in maize and dried cassava and, because of its boring activities, its is capable of damaging a large variety of commodities including other food commodities, wooden objects and drying timber, and leather. This pest can cause more than twice the weight loss in maize as would be expected from infestation by indigenous insect pests such as *Sitophilus zeamais* (Motsch.) (Dick, 1988)

Weight losses caused by *P. truncatus* were first measured in western Tanzania where farmers were found to lose a mean of 9% of their stored maize during up to six months storage (Hodges et al., 1983), although some

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farmers lost as much as 35%. These levels of loss were derived from single spot estimates and therefore do not reflect what occurs over entire storage season of 10 months or more. Over the course of a nine month storage season in Arusha, Tanzania dry weight loss rose to more than 30% (Keil, 1988; Henkes, 1994) and similar observations have been made in West Africa (Pantenius, 1988). However, although these observations include damage to grain by all storage insect pests including *Sitophilus* spp. as well as *P. truncatus*, they do not take into account the declining quantity of grain in store as the season progresses; grain is removed both for consumption and sale. These calculated losses therefore grossly overestimate the real losses, caused by *P. truncatus* and other insects, farmers' suffer during the course of a storage season.

During a FAO extension and control campaign conducted in western Tanzania between 1984 and 1987 to help farmers cope with *P. truncatus*, losses sustained by 105 farmers in three villages were assessed during a storage season. When food removals for home consumption were taken into account the real food loss over a period of 7 – 9 months was less than 2% (Golob, 1988). This is no greater than losses which would normally be caused by indigenous insect pests, i.e. about 2 – 3% (Tyler and Boxall, 1984). These low levels were the result of farmers taking action to control *P. truncatus* by applying insecticide immediately they saw the beetle in their maize, preventing the build up of pest populations.

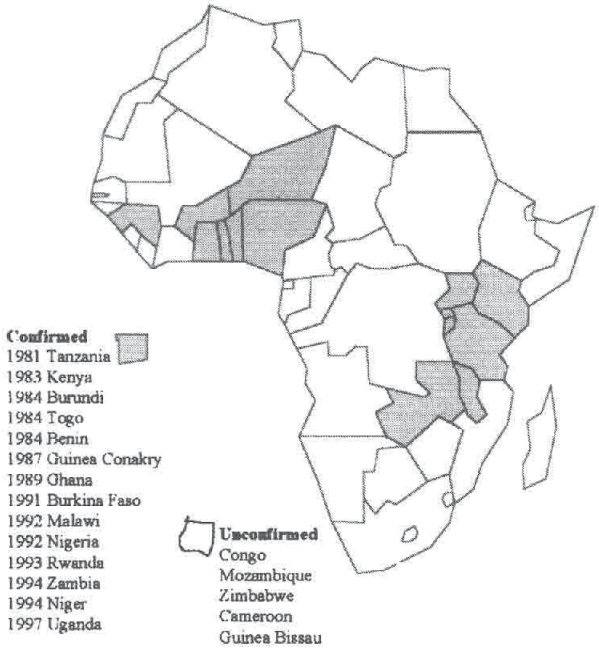


**Fig. 1.** Current distribution of *Prostephanus truncates* (Horn), the Large Grain Borer, in Africa.

When Tanzanian farmers first became aware of the magnitude of the problem caused by *P. Truncatus*, they tried very many procedures to control it. Their methods include spreading grain in a thin layer to use the heat from the sun to drive away or kill the beetles, subjecting infested cobs to heat and smoke above the kitchen fire, and spraying cobs with DDT or endosulphan. None of these methods were effective and when it was demonstrated that the pyrethroid, permethrin, would control *P. truncatus* very easily farmers readily adopted the recommended method of shelling their grain and applying permethrin 0.5% dust to the grain (Golob, 1991). This method (later modified by replacing the insecticide with a cocktail containing permethrin and pirimiphos-methyl) represented a major change to traditional storage practice because maize was normally stored on the cob. In West Africa, farmers were much more reluctant to shell their maize and methods devised to enable them to treat maize on the cob (Boxall and Compton, 1996). These methods were sprinkling water based insecticide solutions on to the husk leaves, subjecting the wooden storage platform to intense heat, replacing infested timbers used in the store, raising the temperature of the cobs in the store by covering them with polythene sheeting, and removing any infested cobs, grain or other crop residues. Similar suggestions for treating both cobs and grain were produced in Kenya (Giles et al., 1995) and the application of permethrin sprays to husked cobs in Tanzania was found to be very effective in preventing *P. truncatus damage* as long as the treatments were applied so after harvest, before the pest becomes established in the maize (Golob and Hanks, 1990).

Biological control of *P. truncatus* by releasing a natural enemy, the histerid beetle *Teretriosoma nigrescens*, was first attempted in Togo, West Africa (Biliwa et al., 1992) and subsequently in Kenya (Giles et al., 1996). This method does not require intervention by farmers and so its effectiveness is independent of such problems related to misuse of chemicals during application, non-availability of chemicals when most required and incorrect timing of treatments. However, because farmers are not really involved in the release of the predator they are unlikely to appreciate the effects on the pest population and loss reduction, if these occur. Initial studies on the impact of the predator have concentrated on observing its spread and loss reduction in experimental maize stores (Borgemeister et al., 1997), it is too soon to evaluate impact on farms. Furthermore, continued use of insecticide alongside biological control is likely to nullify the effects of the predator in some circumstances as this beetle is more susceptible to the chemicals used to control *P. truncatus* than the pest itself (Golob et al., 1994). *T. nigrescens* has not yet been released in Tanzania though there are plans to do so (it would not be surprising if the beetle had already become established from Kenya).

Despite these alternative strategies, in East Africa in

particular, the extension services have concentrated on the simple recommendation of shelling maize, treating it with Actellic Super Dust (ASD) and storing it in an appropriate container (e.g Golob, 1991). At the time *P. truncatus* became established in Tanzania, maize was mostly stored on-the-cob and husked. The exception to this occurred in Arusha Region where maize has long been regarded both as a food and cash crop

The survey, which is the subject of this paper, was conducted to determine the ways farmers have coped with the *P. truncatus* problem in Tanzania during the last two decades. The only other study of this type was conducted during the FAO control campaign during 1986 and 1987 (Golob, 1991) during a period when the control recommendations were being actively promoted. Since that time, the extension services in Tanzania have been under severe financial constraint and the effort to promote good storage practice has declined markedly.

## Methods

The study was conducted four villages in each of six regions (Table 1). With the exception of Kilimanjaro region, villages were selected from one district in each region. Each survey team of four enumerators spent two days in each village In each village, RRA techniques were used to understand farmer's perceptions of post-harvest problems, within a more general context of livelihood and food security strategies. This was complemented by a market traders checklist and a questionnaire sample survey, administered to 350 farmers. Sample survey questions focused on both maize and dried cassava production, storage and sale, and comparisons were made between the issues of current importance and concern and those which were important about 15 years ago when P. truncatus first became established in the area.

Where farmers had food remaining in store a spot estimate of percentage weight loss was estimated. The method used was based on a visual inspection of the commodity in store as developed by Compton (in press) This method relies upon the subdivision of cobs or cassava chips into various damage categories based upon their appearance Each category or class is then related to a weight loss previously calculated from standard samples This method could not be applied to samples of shelled maize, instead a simple estimate of the damage was recorded The estimates were conducted on 20 cobs or cassava chips and on 5kg lots of maize grain. Before samples were collected the commodity was stratified on the basis of variety, store type and pest control applied Samples were then collected from each of the strata identified.

**Table 1.** Villages which participated in the study

| Region | District | Village |
|---|---|---|
| Iringa | Iringa | Kiwere |
| | | Mgera |
| | | Nzihi |
| | | Chamdindi |
| Rukwa | Mpanda | Songambele |
| | | Mnyaki |
| | | Ikolongo |
| Morogoro | Kilosa | Rubeho |
| | | Msingisi |
| | | Ukwamami |
| | | Ihenje |
| Arusha | Babati | Mamire |
| | | Chasimba |
| | | Singe |
| | | Dareda |
| | | Riroda |
| Kilimanjaro | Mwanga | Lembeni |
| | | Mwembe |
| | | Rundugai |
| | | Magadani |
| Tabora | Tabora Rural | Isikizya |
| | | Magiri |
| | | Inala |
| | | Itonjanda |

Note: In Rukwa Region severe local flooding prevented access to many villages and only three could be visited during the survey

## Focus of the Paper

This paper presents results from the sample survey insofar as they relate to maize. Information gathered on cassava, and the findings from the group discussions and market traders will be presented elsewhere. In line with this focus on maize, the objectives and hypotheses for the paper are as follows:

### Objectives

- To assess the role played by *P. truncatus* in determining changes in production, storage and marketing of the maize crop during the period between the first reports of *P. truncatus* in the country and the current time, a period of more than 15 years.
- To assess the factors determining the role played by *P.*

*truncatus* in these stages of the commodity system, in particular the impact of insecticide treatment.

### Hypotheses

(a) Quantity of maize harvested has decreased because *P. Truncatus* is forcing farmers to switch out of the crop.
(b) HYV uptake has been adversely affected due to increased susceptibility of these varieties to *P. truncatus* in comparison with traditional varieties.
(c) The length of time that maize is stored has fallen, as farmers sell their maize early to avoid *P. truncatus* damage.
(d) *P. truncatus* represents a major problem for farmers and they are unable to cope with it.

## Results and Discussion

### Context

The period since LGB became established in Tanzania has seen major changes in the provision of agricultural services. Since agricultural market liberalisation was introduced, government subsidies for agricultural inputs have been removed and insecticides, including ASD, have risen in price. In addition, the reduced role of government control over agricultural marketing has placed increased emphasis on the quality of on-farm storage of grains (Tyler and Bennet, 1993). During the 1990's, production of maize has been particularly influenced by adverse climatic conditions, mostly drought. The impact of LGB on the maize commodity system in Tanzania has been conditioned by these factors.

### Production levels

Figure 2a and 2b illustrates the production of maize, which has occurred in recent years in both normal years and in those when rainfall has been lacking. In drought years almost all of this maize is stored for home consumption and even in other years most is stored, including in Arusha (Figure 3a and 3b). Sale to provide income is not the prime function of producing maize (Figure 4), rather it remains a primary source of food for the family.

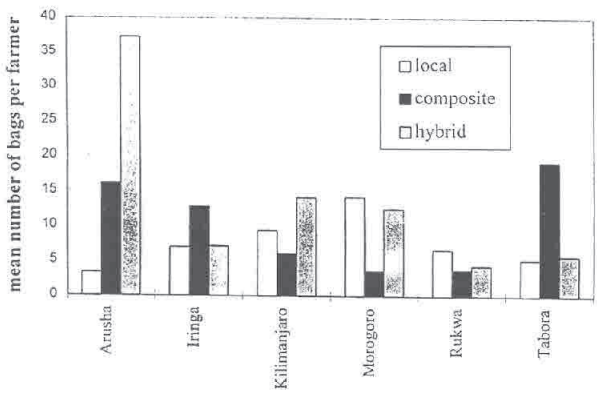


**Fig. 2a.** Quantity of maize harvested in a normal year.

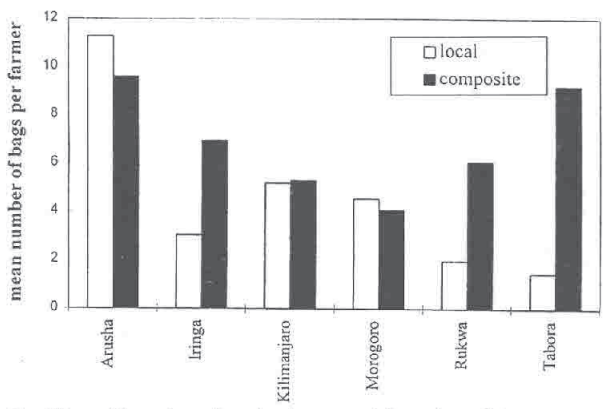


**Fig. 2b.** Quantity of maize harvested in a drought year.

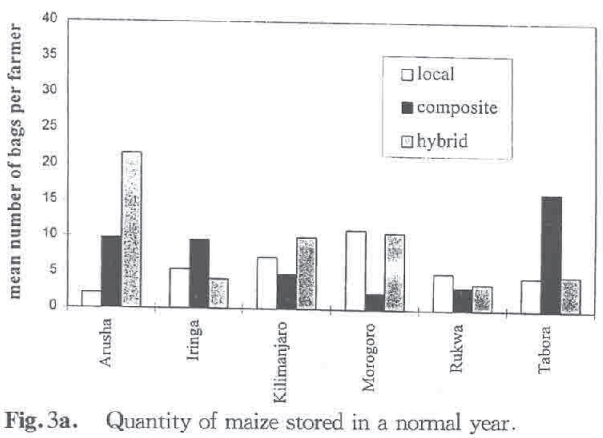


**Fig. 3a.** Quantity of maize stored in a normal year.

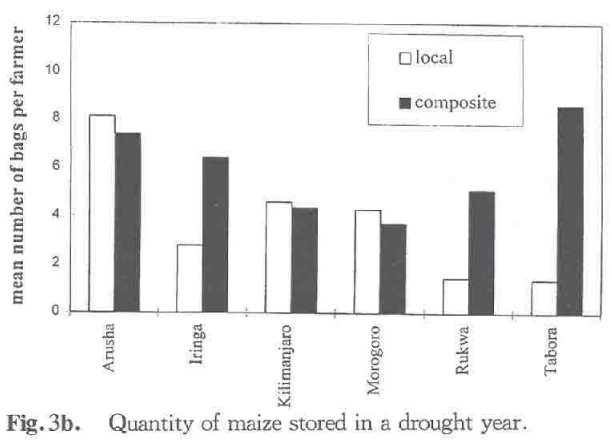


**Fig. 3b.** Quantity of maize stored in a drought year.

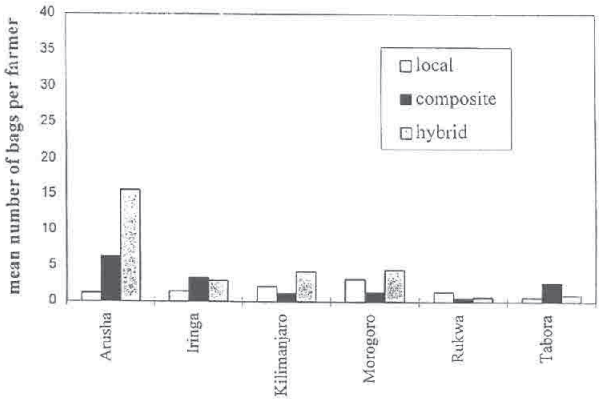


**Fig. 4a.** Quantity of maize sold in a normal year.

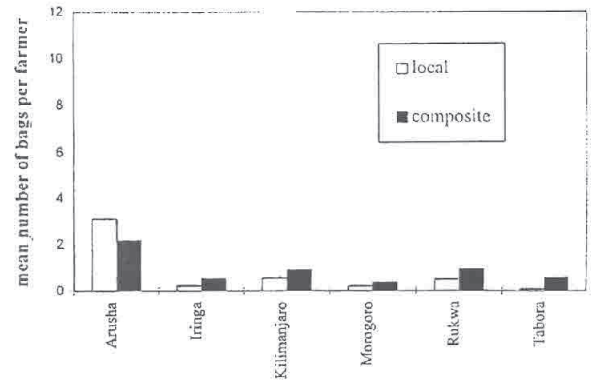


**Fig. 4b.** Quantity of maize sold in a drought year.

## Role of *P. truncatus* in maize harvest

In three of the regions there has been a significant reduction in the quantity of maize harvested but this change was not induced by *P. truncatus*; in none of the regions was production influenced by the pest (Figure 5). Most farmers interviewed said either that there had been no change in quantity of maize harvested in comparison to 15 years ago (Arusha, Kilimanjaro, Tabora) or that harvest had reduced but this had been due to factors other than LGB (Morogoro, Rukwa). In Iringa, the picture was more complicated with roughly 40% of farmers saying that there had been no change, 30% saying that there had been a decrease (not due to LGB) and the remainder stating that there had been an increase.

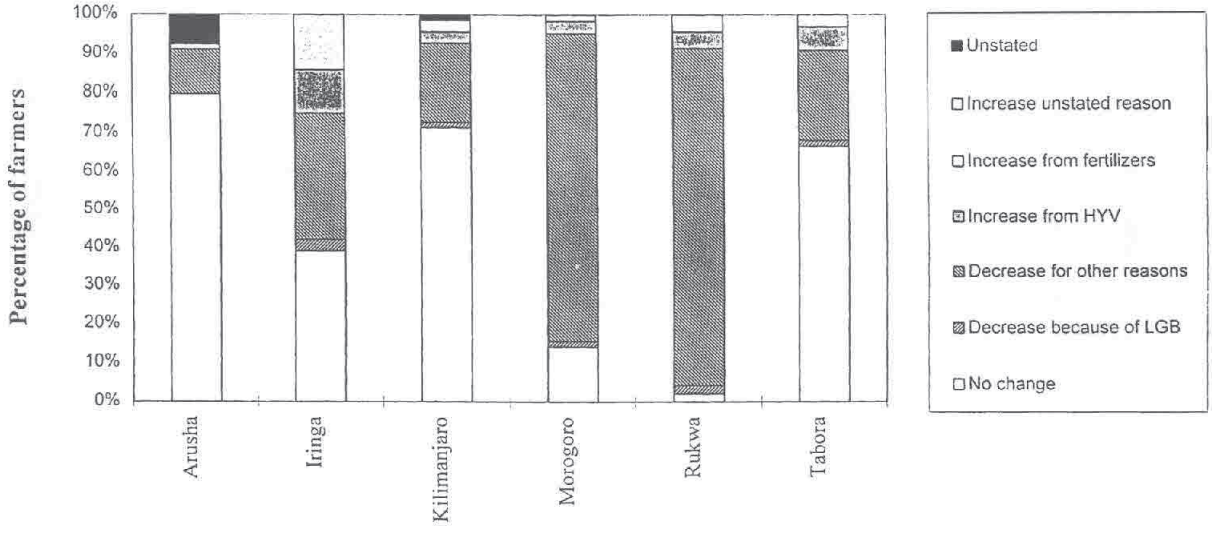


**Fig. 5.** Reasons for the changes in the quantity of maize harvested at present in comparison with 15 years ago.

## Role of *P. truncatus* in maize varieties

The majority of farmers are currently cultivating the same varieties now as they were 15 years ago (Figure 6). Those farmers, who are using different varieties, especially in Morogoro, are doing so because improved varieties have become available. There are now many international seed companies developing and distributing maize seed in Tanzania, whereas before 1990 seed was only available through the Tanzanian Seed Company, a parastatal organisation. New varieties, particularly hybrids, have been developed for the high potential areas and so are used in districts in Iringa and Morogoro. HYVs are more susceptible to insects, including *P. truncatus* during storage, but this has not induced farmers to change varieties except in Kilimanjaro.

## Role of *P. truncatus* in duration of storage and volume of sales at farm level

Figure 7a, 7b and 7c indicates the length of time after

harvest that farmers have maize in storage on farm. Looking across all regions, Figure 7b shows that farmers exhaust stocks of maize between 8 and 10 months after harvest in a non-drought year. In a drought year this reduces to between 5 and 6 months.

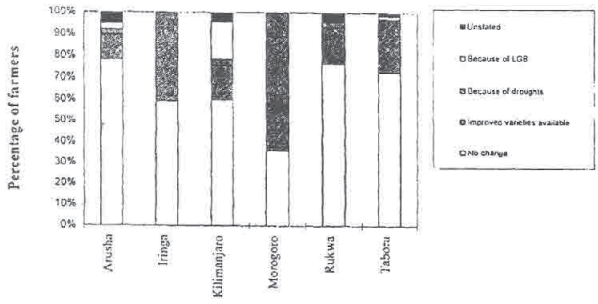


**Fig. 6.** Reasons for changes in the varieties of maize cultivated at present compared with 15 years ago.

Figure 8 shows that at least 50% of farmers stated that there had been no change in the duration of maize storage in comparison with 15 years ago. In Arusha and Iringa, 80% of farmers stated 'no change', in Kilimanjaro, 65%, and in Morogoro, Rukwa and Tabora around 50%. In Morogoro and Rukwa, 30 – 40% of farmers stated that there had been a decrease due to non-LGB reasons (most commonly a reduction in production). It was only really in Tabora and Kilimanjaro that a significant minority of farmers attempted to avoid the effects of *P. truncatus* by reducing storage and so curtailing the potential period of exposure of maize to the pest: 25% of farmers in Tabora and 15% of farmers in Kilimanjaro had taken such action. Unsurprisingly, in these two regions also some farmers had increased the quantity of maize sold due to *P. truncatus*. (Figure 9). Lower percentages of farmers in other regions had also taken this action (less than 10% in other regions).

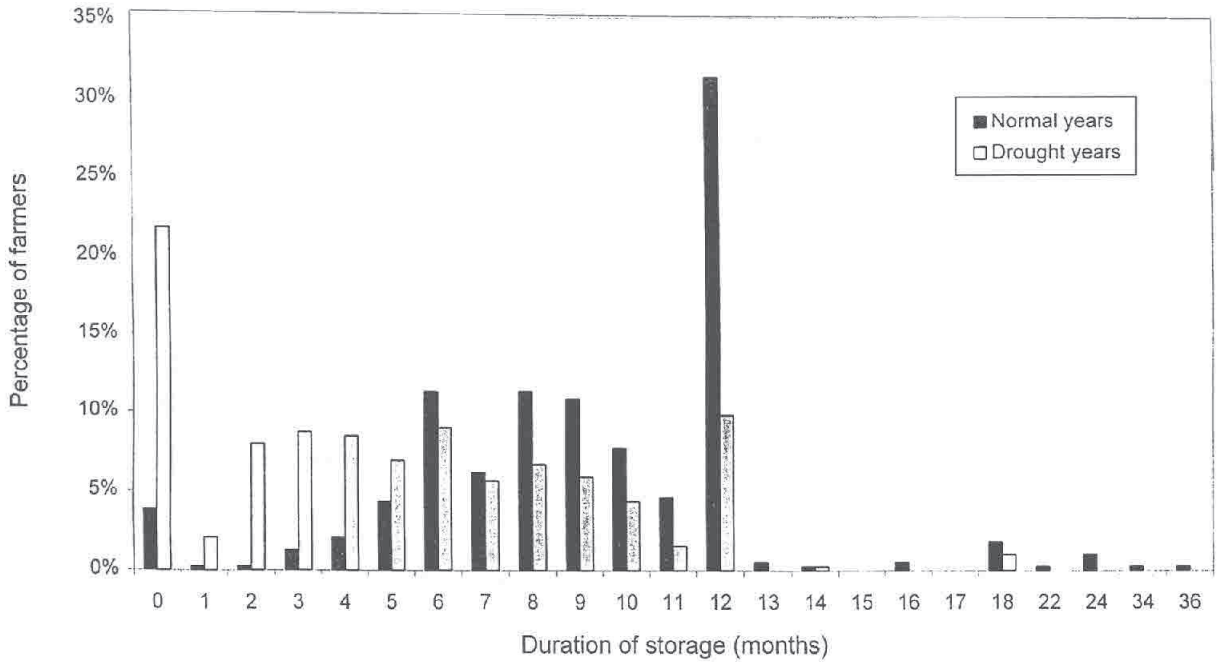


**Fig. 7a.** Duration of maize storage: aggregate for the 6 regions.

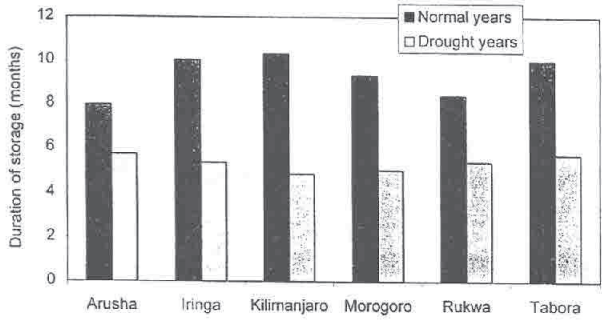


**Fig. 7b.** Average duration of storage (with SEM) by regions.

## Summary

In all the villages surveyed, *P. truncatus* has had no real impact on maize production outcomes at farm level. Impact on storage and marketing outcomes has been more evident, but even here behavioural change has been restricted to a minority of farmers in two regions, Tabora and Kilimanjaro. Taking all regions together, then, hypotheses (a), (b) and (c) are unsupported by the survey evidence. This poses the question: do farmers actually regard the pest as a major problem, and if so, are they able to deal with it? (hypothesis (d)).

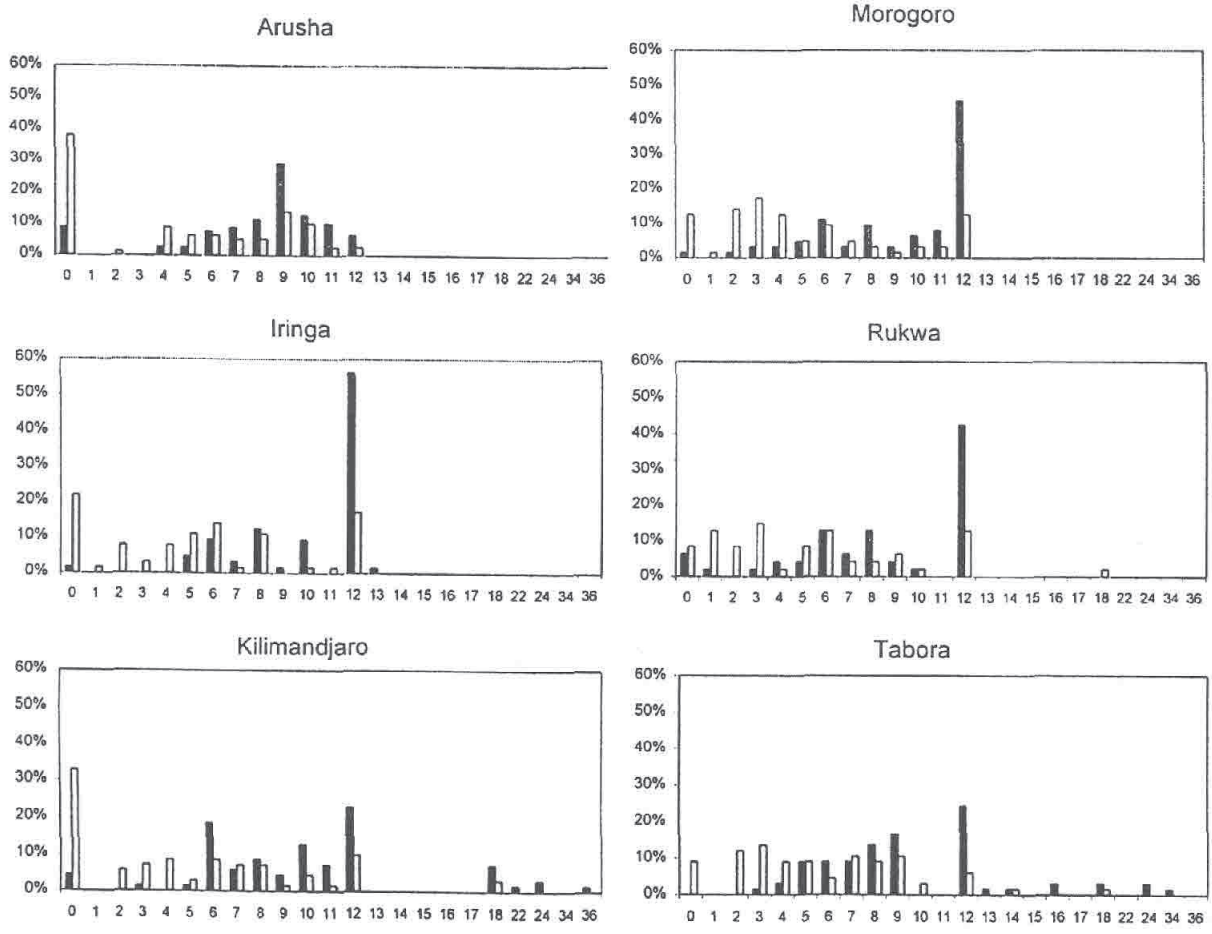


**Fig. 7c.** Frequencies by regions.

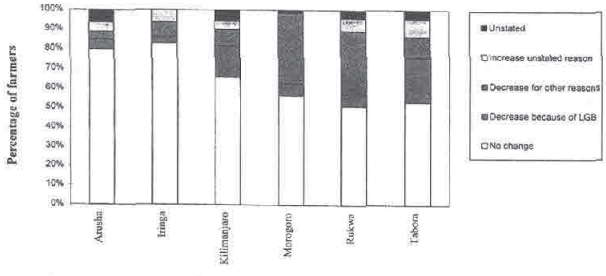


**Fig. 8.** Reasons for the changes in the duration of maize storage at present in comparison with 15 years ago.

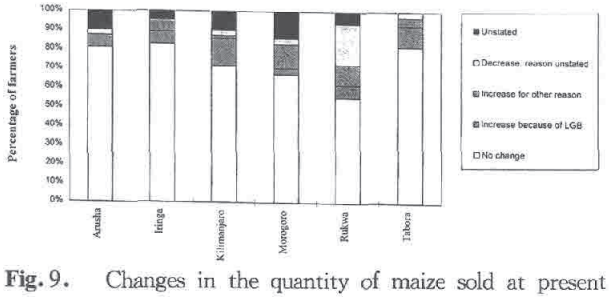


**Fig. 9.** Changes in the quantity of maize sold at present compared with 15 years ago.

## Is *P. truncatus* still regarded as a problem?

Maize producers still regard insects, particularly *P. truncatus*, as being the main storage problem. Figure 10 illustrates the list of storage problems mentioned during the survey and the mean ranking given by farmers. A similar ranking was produced for maize intended for sale. When the first four most important problems are considered, LGB, other Insects, rodents and mould, it becomes clear just how *P. truncatus* dominates concern (Figure 11).

## Coping strategies for *P. truncatus*

Farmers have been willing to use insect-susceptible varieties of maize because they are aware that insect problems in store can be alleviated by the application of insecticide, particularly Actellic Super Dust (ASD). Most farmers believed ASD was effective against *P. truncatus* and other storage insect pests (Figure 12). Less than 5% of farmers who used this insecticide were not satisfied with the results obtained except in Kilimanjaro where 20% were dissatisfied. In this region, there were many batches of the

insecticide dust that had been adulterated with non-active filler so reducing its efficacy. Elsewhere, reduced activity was often associated with improper application, either by reducing the dosage or by treating maize on-the-cob rather than grain.

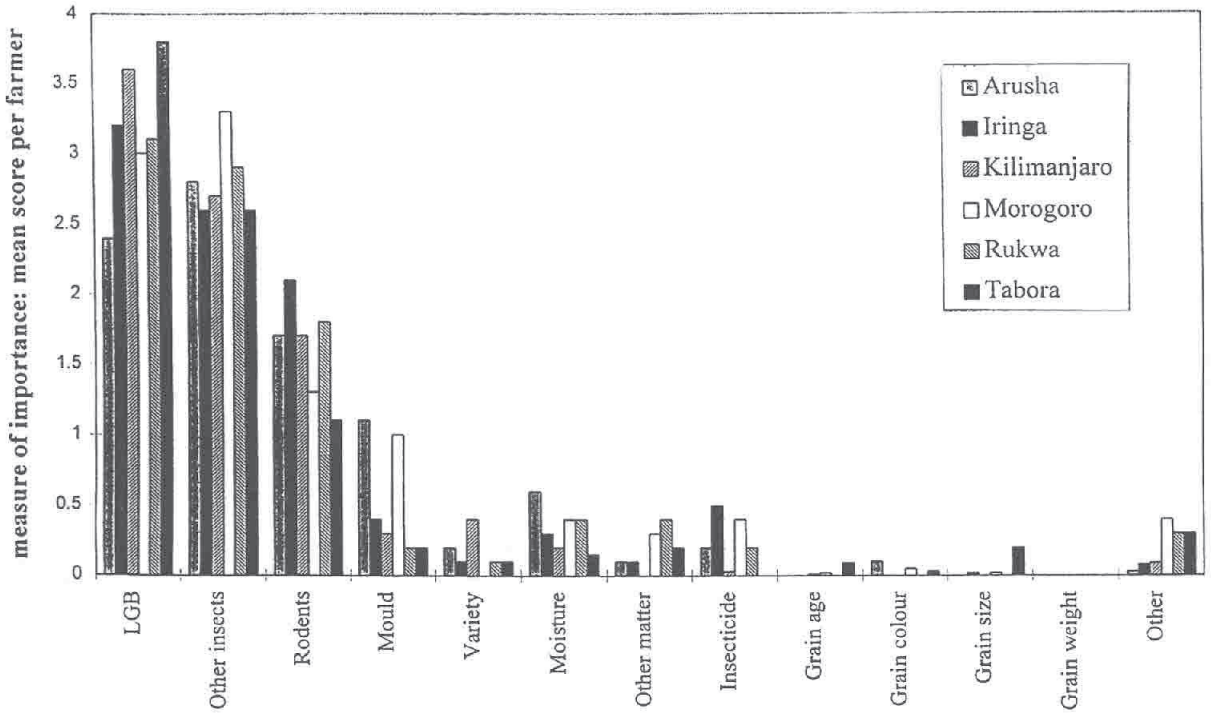


**Fig. 10.** Problems associated with maize stored for food consumption.

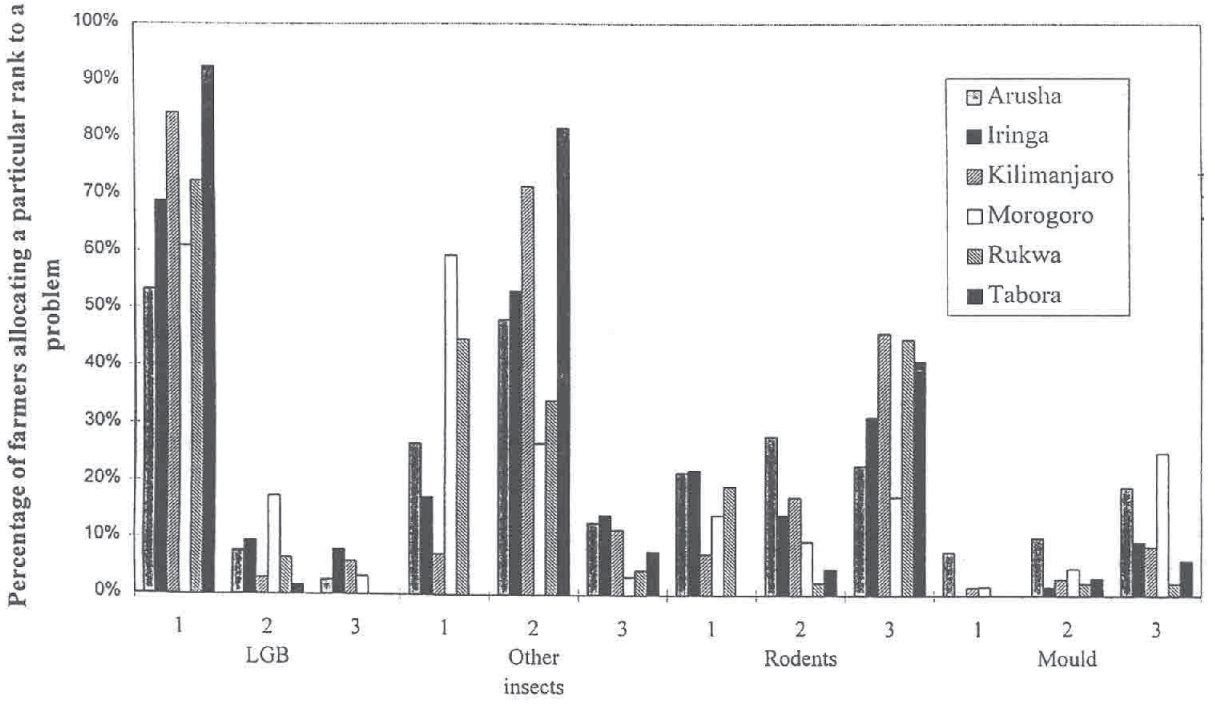


**Fig. 11.** Ranking given by farmers to the four main problems associated with maize stored for food.

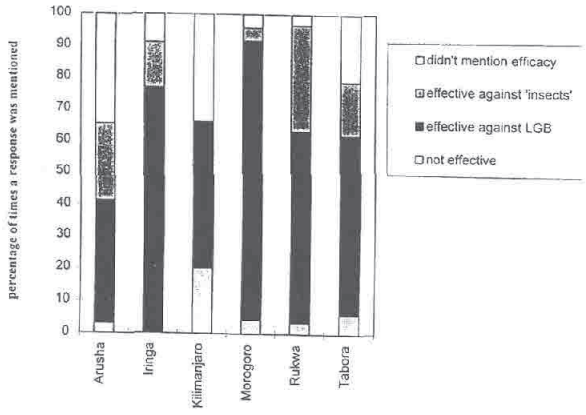


**Fig. 12.** Farmers preparations of efficacy of ASD.

ASD is regarded as the main method of protecting maize during storage in all regions surveyed except for Morogoro (Figure 13), where less than half the farmers use this chemical through choice. Many in this region apply insecticide in the form of a spray after diluting Actellic Emulsifiable Concentrate. This chemical is similar to ASD but it does not contain the pyrethroid component, permethrin. Although *P. truncatus* is particularly susceptible to permethrin it will also succumb to Actellic (pirimiphos-methyl) particularly during the first months after grain is treated. In Morogoro there has been a decline in the duration of storage (Figure 6) and it is likely that application of Actellic alone will be sufficient to provide protection against insect pests, including *P. truncatus*. Other chemicals are used as storage protection particularly where there is a need to apply insecticide to cash crops such as cotton and tobacco during the production period. These chemicals are often very cheap or even provided free by companies buying the harvested product. However, without exception, these chemicals which include thiodan and DDT, are all far too toxic to apply to grain which is to be consumed. Some farmers still subject their maize to heat and smoke by placing cobs in layers or heaps above the kitchen fire. This is an established traditional practice which is effective in controlling most storage pests but has very limited effect against *P. truncatus*. Other traditional methods are also still used, including mixing maize with leaves of various plants such as tobacco, applying ash from the kitchen fire or from burnt animal dung. None of these methods effectively controls *P. truncatus*.

In order to use ASD effectively, maize must be shelled before treatment. As shelling was never a traditional practice in most regions of Tanzania this activity necessitates a change in the type of storage container used. Storage structures have changed between the time LGB was introduced and the current time. Fifteen years ago most families stored maize cobs in cylindrical cribs located outside the house or on platforms in the roof eaves above the kitchen fire or outside the house, the latter being used for drying as well as for storage (Figure 14). Many farmers have since switched to storing in sacks made from jute, hessian or woven polypropylene (Figure 15). In Tabora, Kilimanjaro and Arusha there are still many farmers who use platforms and who therefore store mainly maize on the cob. This reflects an attitude common to many families who are unwilling to take action to prevent LGB problems by shelling and treating until they see insects in their commodity. Thus many families store maize on-the-cob on platforms before shelling later in the year when the insect becomes apparent and putting the grain into sacks.

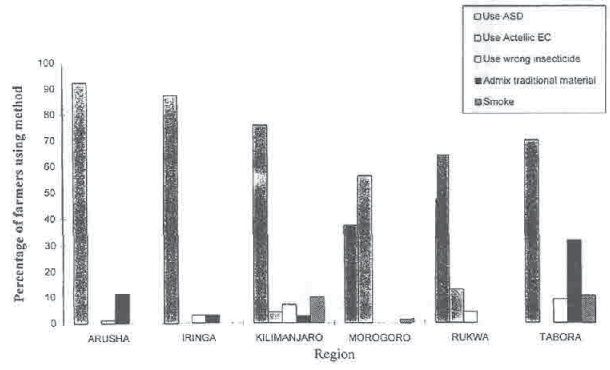


**Fig. 13.** Use of different methods of protecting maize against insect pests during storage.

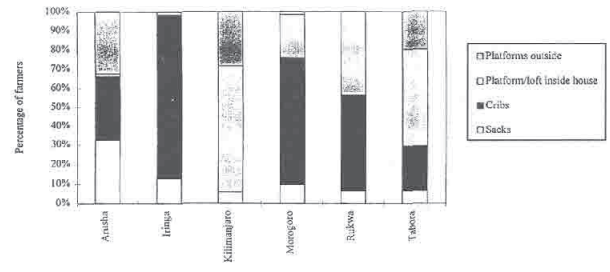


**Fig. 14.** Structures use for maize storage 15 years ago.

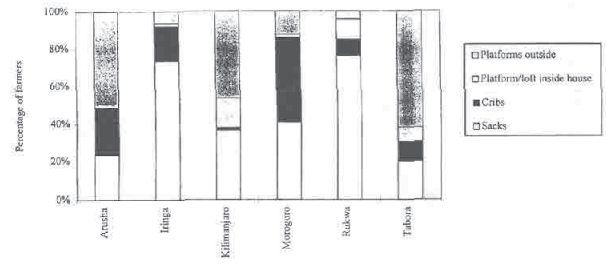


**Fig. 15.** Strictures currently used for maize storage.

## Conclusion

With the exception of a minority of farmers in Tabora and

Kilimanjaro, *P. truncatus* does not appear to have influenced the insect is consistently regarded as being the most potent storage problem. The reason why outcomes have not changed in the context of the *P. truncatus* threat is that farmer behaviour has changed to combat the pest. The key behavioural changes have been a much more widespread use of ASD and, in Morogoro, Actellic EC, and a concomitant increase in the incidence of shelling of maize (with the exception of Morogoro) and decrease in crib storage

The fact that farmers appear to be coping well with *P. truncatus* over 10 years after the original extension campaigns, in the context of increased insecticide prices and a generally poorly functioning government agricultural extension system, bodes well for other countries in Africa currently experiencing the pest. The Tanzanian experience highlights the fact that a well orchestrated extension campaign which stresses the simple 'shell, treat, and store' message can lead to sustainable farmer coping strategies which can keep the *P. truncatus* threat at bay. Before becoming too optimistic about this, however, it should be remembered that the high prices of ASD in many African countries may put the 'shell, treat, and store' solution out of the reach of the poorest farmers This is an issue which merits further investigation.

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