Study of an outbreak of Prostephanus truncatus (Horn) in Tanzania (G164)

Tropical Products Institute

G 164

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P. Golob and R. Hodges

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Tropical Products Institute 56/62 Gray's Inn Road London WC1X 8LU
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We are grateful to the Government of the Republic of Tanzania for giving us the opportunity to study this unique pest outbreak and allowing the publication of this report.

Wherever we travelled we found the co-operation of government staff to be excellent. We would particularly like to thank Mr Magasini and Mr R. Dunstan (of the Ministry of Agriculture/Overseas Development Administration Armyworm Project) for easing our stay up-country, for providing often-needed equipment for repairing the vehicles and especially for providing sterling support when we most needed it, during the long, tedious, sample analysis sessions. The help of Mr A. Mushi and Mr J. Tunstall during the initial survey visits in the Tabora district was also much appreciated.

Summaries

SUMMARY

A comprehensive survey of the Tabora region of Tanzania was undertaken to observe the distribution of *Prostephanus truncatus* (the greater grain borer), a pest of stored maize. The pest was found in grain stores in 46 villages from a total of 56 examined, in all four districts of the region, being absent only in eastern Igunga, a sorghum-growing area, and in the southern part of the Tabora district. The pest was found in the Shinyanga region and in markets in the Mwanza region and at stores at Kilosa in the Morogoro region.

After 4–6 months storage, maize samples collected from the villages in the Tabora region exhibited as much as 34% weight loss. Damage on this scale in a period of very dry weather, in very dry maize (average 11.2% moisture content) is extraordinarily high and demonstrates the destructive nature of this pest. Without doubt the pest will cause both a serious and widespread grain shortage in the region later and a dearth of seed grain for the coming growing season. Besides attacking maize, the pest also heavily damaged cassava and, to a lesser extent, other commodities such as groundnuts. Wooden implements and storage structures were also damaged.

From the survey it is concluded that *P. truncatus* has become very well established in West Central Tanzania and is of major importance as a pest of stored produce. The outbreak must be seen to be of grave significance to the region. Unless effective measures to control and contain it are rigidly enforced the pest will spread throughout the rest of the country. The beetle poses a very real threat throughout East and Central Africa.

Insecticide trials were established to assess the effectiveness of different treatments for the control of this pest in farm storage. These trials will continue.

This account of the investigation was prepared whilst the team was in Tanzania. It was presented together with specific recommendations for the control and containment of the infestation at a final meeting between the team and the Ministry of Agriculture. The Tanzanian authorities have already taken steps to inform the international community through the FAO. They also agreed that the scientific results of the investigation could be made generally available.

RÉSUMÉ

Une exploration approfondie de la région de Tabora en Tanzanie a été entreprise pour observer la distribution de *Prostephanus truncatus* (le grand perceur des grains), un insecte nuisible du maïs emmagasiné. L'insecte a été trouvé dans des réserves de grain dans 46 villages sur les 56 villages explorés, dans les quatre districts de la région, étant absent uniquement dans l'Igunga oriental, une région de culture de sorgho, et dans la partie sud du district de Tabora. L'insecte nuisible a été trouvé dans la région de

Shinyanga et sur les marchés dans la région de Mwanza et dans les réserves à Kilosa dans la région de Morogoro.

Aprés une conservation de 4 á 6 mois, les échantillons de maïs prélevés dans les villages de la région de Tabora ont présenté une perte de poids atteignant 34%. La détérioration sur cette échelle dans une période de trés grande sécheresse, dans du maïs trés sec (teneur en humidité moyenne 11,2%), est extrêment élevée et montre la nature destructrice de cet insecte nuisible. L'insecte sera sans aucun doute plus tard la cause d'une manque grave et étendu de grain dans la région, et d'une pénurie de graines de semence pour la saison de culture à venir. En plus du maïs, l'insecte nuisible a également sérieusement détérioré le manioc et, à un moindre degré, d'autres denrées telles que les arachides. Les matériaux en bois et les structures des entrepôts ont également été détériorés.

En se fondant sur cette enquête, on conclut que *P. truncatus* s'est solidement installé à l'ouest de la Tanzanie centrale et qu'il est d'une importance majeure en tant qu'insecte nuisible des produits emmagasinés. L'infestation doit être considéré comme étant grave pour la région. A moins que des mesures efficaces ne soient strictement imposées pour lutter contre cette infestation et la contenir, l'insecte nuisible se répandra dans le reste du pays. Il constitue une menace tout à fait réelle dans toute l'Afrique orientale et centrale.

Des essais d'insecticides ont été entrepris pour évaluer l'efficacité de différents traitements en vue de la lutte contre cet insecte nuisible dans les réserves des fermes. Ces essais seront poursuivis.

Ce compte-rendu de l'étude a été préparé pendant que l'équipe se trouvait en Tanzanie. Il a été présenté, en même temps que des recommandations spécifiques pour la lutte contre l'infestation et son arrêt, à l'occasion d'une conférence finale réunissant l'équipe et le Ministère de l'agriculture. Les autorités tanzaniennes ont déjà pris des mesures pour informer la communauté internationale par le canal de la FAO. Elles admettent également que les résultats scientifiques de l'étude pourraient être rendus publics.

RESUMEN

Se llevó a cabo un estudio cuantioso en la región Tabora de Tanzanía para observar la distribución del *Prostephanus truncatus* (el gran horadador del grano), una plaga del maíz almacenado. La plaga se detectó en los graneros de 46 aldeas de un total de 56 examinadas en los cuatro distritos de la región, estando ausente solamente en la región productora de sorgo de la Igunga oriental y la región meridional de Tabora. La plaga fue hallada en la región de Shinyanga, en los mercados de la región de Mwanza y en los graneros de Kilosa en la región de Morogoro.

Después de 4–6 meses de almacenaje, las muestras de maíz recogidas en las aldeas de la región de Tabora registraron hasta un 34% de pérdida de peso. Daños de esta escala durante períodos de tiempo sumamente seco y en maíz muy seco (media de un 11,2% de contenido húmedo) son extraordinariamente altos y demuestran la naturaleza destructora de esta plaga. Sin lugar a dudas, la plaga causará una grave y extendida escasez de grano en la región en el futuro, así como la falta de semilla para la temporada de cultivo siguiente. Además de atacar el maíz, la plaga también causa graves daños en la mandioca, y con menor fuerza ataca otros productos tales como cacahuetes, aperos de madera y estructuras de almacenaje.

A través del estudio se ha llegado a la conclusión de que el *P. truncatus* se ha establecido sumamente bien en la región central occidental de Tanzanía y reviste importancia primordial como plaga de productos almacenados. La epidemia debe ser considerada como de grave importancia para la región. A menos que sean adoptadas

medidas efectivas para controlar y contener la plaga, ésta se propagrá por el resto del país. El escarabajo plantea una amenaza sumamente real en todo el Africa Oriental y Central.

Se establecieron ensayos de insecticidas para evaluar la efectividad de diferentes tratamientos para el control de esta plaga en los graneros agrícolas. Estos ensayos serán continuados.

Este informe de la investigación fue preparado mientras que el equipo permaneció en Tanzanía. Fue presentado junto con recomendaciones para el control y detención de la plaga en una reunión final celebrada entre el equipo y el Ministerio de Agricultura. Las autoridades de Tanzanía han adoptado ya medidas para informar a la comunidad internacional a través de la FAO. También acordaron que los resultados científicos de la investigación habrían de ofrecerse disponibles de manera general.

Study of an outbreak of *Prostephanus truncatus* (Horn) in Tanzania

INTRODUCTION

During 1980 farmers storing maize and cassava in the Tabora region of Tanzania recognised damage caused by an unfamiliar beetle. The Tanzanian Plant Protection Authority conducted a preliminary survey of the region in 1981, and dispatched specimens to the British Museum (Natural History) for identification. The pest was found to be the greater grain borer, *Prostephanus truncatus* (Horn). This beetle has previously only been known as a pest of stored maize in Central America. Its presence has also been recorded from a few other locations, but never Africa. A key for the identification of *P. truncatus* is given in Appendix I (*see* p.17).

Very little information about the pest was available to the Tanzanian authorities. They sought help from the Tropical Products Institute (TPI) part of the Overseas Development Administration (ODA), who responded by offering the assistance of a two-man team, Dr P. Golob and Dr R. Hodges of TPI Storage Department, to study the outbreak. In Tanzania the team was joined by Mr R. Dunstan and Mr Magasini, both normally assigned to the ODA/Ministry of Agriculture Armyworm Project and, for a short while, by Mr J. Tunstall, also of the Armyworm Project, and Mr A. Mushi, Pest Control Co-ordinator, Northern Tanzania. The TPI team was in Tanzania between 28 August and 7 October 1981, during which period extensive travel was made in Tabora and some adjoining regions.

The principal objectives of the mission were:

(i) To survey the distribution of *P. truncatus* within the Tabora region and to determine its spread in other regions of the country.

(ii) To determine the extent of damage by:
   (a) estimating the insect population,
   (b) estimating the loss of weight caused at the time of the survey.

(iii) To set up field trials to identify a suitable grain protectant for on-farm use against *P. truncatus*.

THE SURVEY

Methods

Fifty-six towns and villages from a total of 369 throughout the Tabora region were selected and visited to give a representative sample for each of the four districts. A farmer in the village whose stored crops were known to have suffered *P. truncatus* damage was interviewed using a questionnaire (*see* Appendix II, p.20). Samples of 36 maize cobs or approximately 3 kg of maize grain were collected from each farmer for subsequent laboratory analysis (*see* Appendix III, p.21).

Outside the Tabora region visits were made to local trading centres to examine maize sold in markets. Villages were also visited where previous information indicated the presence of pests. Samples were not collected outside Tabora as it was impractical to undertake analyses.

Observations

A summary of the results including the preliminary laboratory analysis of infested samples can be found in Table 1 (*see* pp.7 and 8). The locations visited throughout Tanzania are shown on Map I (*see* p.9) and the detailed survey of the Tabora region on Map II (*see* p.10).

Tabora region

The beetle was widely distributed in the Tabora region but was absent from two distinct areas (*see* Map II). It had apparently not spread to the Utibona complex of villages in the south of the Tabora rural district and was absent from eastern Igunga. The latter is a sorghum-growing area and this crop is apparently not attacked. In Igunga only the maize-growing areas in the west suffered from *P. truncatus* infestation.

Wherever *P. truncatus* occurred in the Tabora region it was an important storage pest. In many cases infestation was extremely serious. After only 3–6 months storage some farmers' stored crops suffered weight losses of above 30% (*see* Table I). For weight losses of this magnitude at least 70% of grains are heavily damaged and are rendered valueless either as seed or food. However, the average estimated weight loss of the infested samples in the whole Tabora region at 3–6 months of storage was 8.7%. There was, therefore, a large variation in the amount of damage found on farms; the reason for this was not apparent. The average weight loss for the Urambo district was lower than for the other districts (*see* Table I). This may be explained by the rather later harvest in Urambo, mostly in June, which resulted in a comparatively shorter storage period before the survey.

No other storage pest has been recorded as causing such severe damage in farmers' stores after such a short period and under such dry conditions. It is noteworthy that the mean moisture content of the maize samples analysed was 11.2% and in only 3 samples from a total of 42 was it 12% or above. In such dry maize the more conventional storage pests have difficulty in sustaining a population increase. *P. truncatus* was clearly tolerant of such dry conditions and no doubt benefits from the absence of any considerable competition of other insect species.

Shelled maize was also heavily infested although it seems likely that in most cases infestation started whilst the grain was on the cob (*see* Plates I and II, p.18). In godowns in Tabora it appeared that *P. truncatus* infestation in shelled yellow maize (imported) had been effectively controlled by fumigation with phosphine gas. The only other crop consistently infested was dried cassava. Some damage to groundnuts was noted in a few cases but no damage to paddy, sorghum or beans was found. Some wooden storage structures, clothing and cooking utensils showed signs of boring.

The estimated maize losses in the Tabora region at 3–6 months into the storage season must be regarded as extremely serious. The amount of viable seed grain available, to those farmers with severe damage to their stored crops, is already drastically reduced and by planting time these farmers will have an inadequate seed supply for a good harvest next year. Similarly, in the case of food grain, many farmers now have insufficient maize to last them until the next harvest. This will result in serious local shortages unless alternative food supplies are made available.

Practical constraints prevented any quantitative analysis of cassava damage on farms. However, it was clear that cassava was extensively damaged when stored on farms where the beetle had damaged maize.

Other regions

P. truncatus was found only in the southern parts of the Shinyanga region. Of particular importance was the presence of the pest in and around the trading town of Kahama since it was being transported from there to other localities. For example, infested maize from Kahama was found in Shinyanga town market but none of the villages investigated around Shinyanga town were, as yet, infested.

Further north in Mwanza town the beetle was found in two markets, having been introduced in maize transported by train or lorry from other locations. Again the surrounding villages appeared to be free of infestation. Of the other regions investigated (*see* Table 1) only in Kilosa, in the Morogoro region, was the beetle in evidence. In this case the team found infested maize, from the previous year's harvest, in a central store. It seems very likely that the source of the infestation was samples received during a base-line survey of losses in central stores throughout the country.

(Subsequent to our visit we have learnt of a report of the beetle in Kilimanjaro region in a consignment of cassava).

Table 1

Results of survey for *Prostephanus truncatus* and preliminary sample analysis

District	Location[a]	*Prostephanus truncatus*[b]	Percentage cobs damaged	Mean percentage grain damaged	Mean percentage weight loss
TABORA REGION					
Tabora	Ibiri	+	100	71.7	32.9
	Igoko	+	2	1	–
	Isala	+		No sample	
	Isira	+	–[c]	14.5	3.3
	Kanyenye	+	–	11.2	4.2
	Kategile	+	36	8.0	4.6
	Kigwa	+	14	0.5	0.2
	Kizenge	+	71	20.2	6.2
	Lulanguru	+	56	12.9	5.5
	Magiri	+		No sample	
	Malongwe	+	90	7.6	2.9
	Mayombo	+	–[c]	11.0	2.8
	Migungamalo	+	92	49.8	20.1
	Mponbwe	+	62	23.2	8.4
	Sikonge	+	66	40.0	16.9
	Tumbi	+		No sample	
	Tabora[d]	+		37.0	8.9
	Uramba	+	22	37.0	11.5
	Utibona III	–	–	–	–
	Utibona V	–	–	–	–
	Mean values:		55.5	22.9	9.2
Nzega	Itobo	+	100	58.0	8.8
	Itunda	+	100	77.2	33.0
	Kampala	+	22	2.5	0.6
	Mambali	+	100	50.5	16.8
	Mbutu	+	–[c]	31.0	2.7
	Mogwa	+		No sample	
	Mwambala	+	95	73.4	34.6
	Nata	+	14	3.3	1.6
	Nkiniziwa	+		No sample	
	Uchama	+	47	5.4	1.5
	Uduka	+	33	33.2	9.0
	Utwigu	+	13	6.6	3.0
	Mean values:		58.2	34.1	11.1

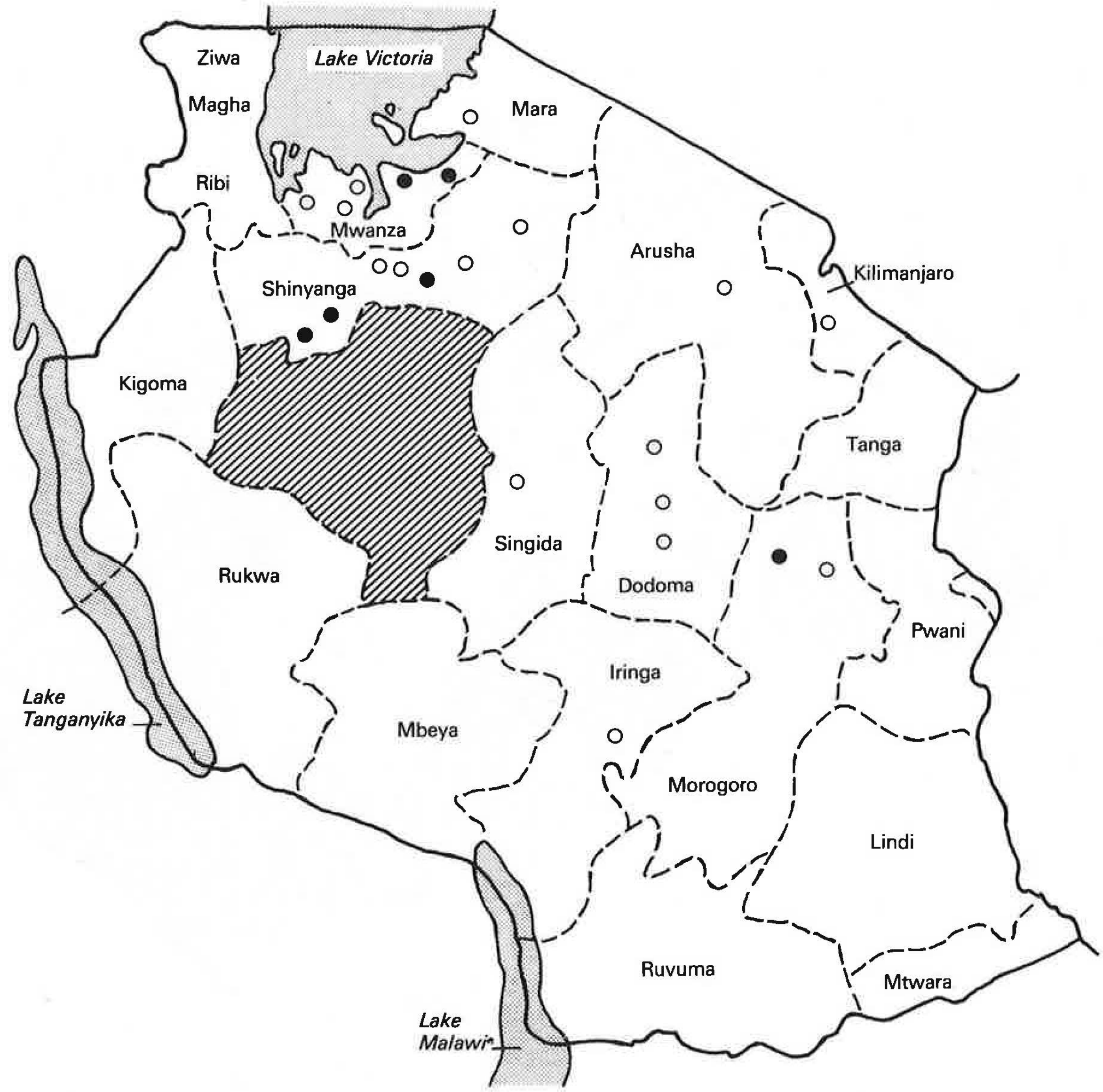
Table 1 ***contd.***

District	Location[a]	*Prostephanus*[b] *truncatus*	Percentage cobs damaged	Mean percentage grain damaged	Mean percentage weight loss
Igunga	Chomachankola mkt[e]	+		No sample	
	Igumo	+	84	8.8	–
	Igunga[f]	–	–	–	–
	Idogonya	–	–	–	–
	Ipumbulya	–	–	–	–
	Kininginila	–	–	–	–
	Kingungu	–	–	–	–
	Mwangungu	–	–	–	–
	Sakamaliwa	–	–	–	–
	Simbo	+	57	13.9	7.1
	Sungwizi	+	12	7.3	2.2
	Ulaya	+	–[c]	40.9	11.0
	Uswaya	–	–	–	–
	Ziba	+		No sample	
	Mean values:		51.0	17.7	6.8
Urambo	Igagala V	+	52	9.2	1.6
	Ikonongo	+	8	1	0
	Isoke	+		No sample	
	Kaliua	+		No sample	
	Ulindwanoni	+	41	27.1	8.0
	Songambele	+	92	60.7	18.6
	Ulyankulu	+		No sample	
	Urambo	+	0	0	0
	Uyowa	+	51	9.2	1.6
	Vumilia A	+	56	20.5	6.5
	Mean values:		42.8	18.1	5.18

Region	Location	*Prostephanus truncatus*
OTHER REGIONS		
Shinyanga	Ibadakull	–
	Kahama	+
	Kilabela	–
	Lalago	–
	Mwakilugula	–
	Shinyanga mkt	+
	Usanda	+
Mwanza	Geita	–
	Mwanza mkt	+
	Nyalikungu mkt	+
	Nyanhwale	–
	Sengerema mkt	–
Mara	Bunda	–
Arusha	Arusha mkt	–
Kilimanjaro	Moshi mkt	–
Singida	Singida[g]	–
Dodoma	Babati	–
	Kondoa near mkt	–
	Dodoma mkt	–
Morogoro	Kilosa[f]	+
	Morogoro central stores and mkt	–

Notes: (a) Place names for Tabora region are taken from *Ramani Ya Vijiji Mkoawa Tabora,* compiled, drawn and printed by Surveys and Mapping Division, Ministry of Lands, Housing and Urban Development, Tanzania, 1977. Other names are taken from Shell Map of Tanzania (1973)–published by Shell & BP, Tanzania Ltd., P.O. Box 9043, Dar es Salaam.
(b) + = *P. truncatus* found at location. – = *P. truncatus* not found
(c) Farmer storing shelled white maize
(d) Imported yellow maize
(e) mkt = market
(f) Central stores
(g) Details with Mr A. Mushi, Plant Protection, Tengeru, Arusha

Map I
Locations surveyed for *Prostephanus truncatus*



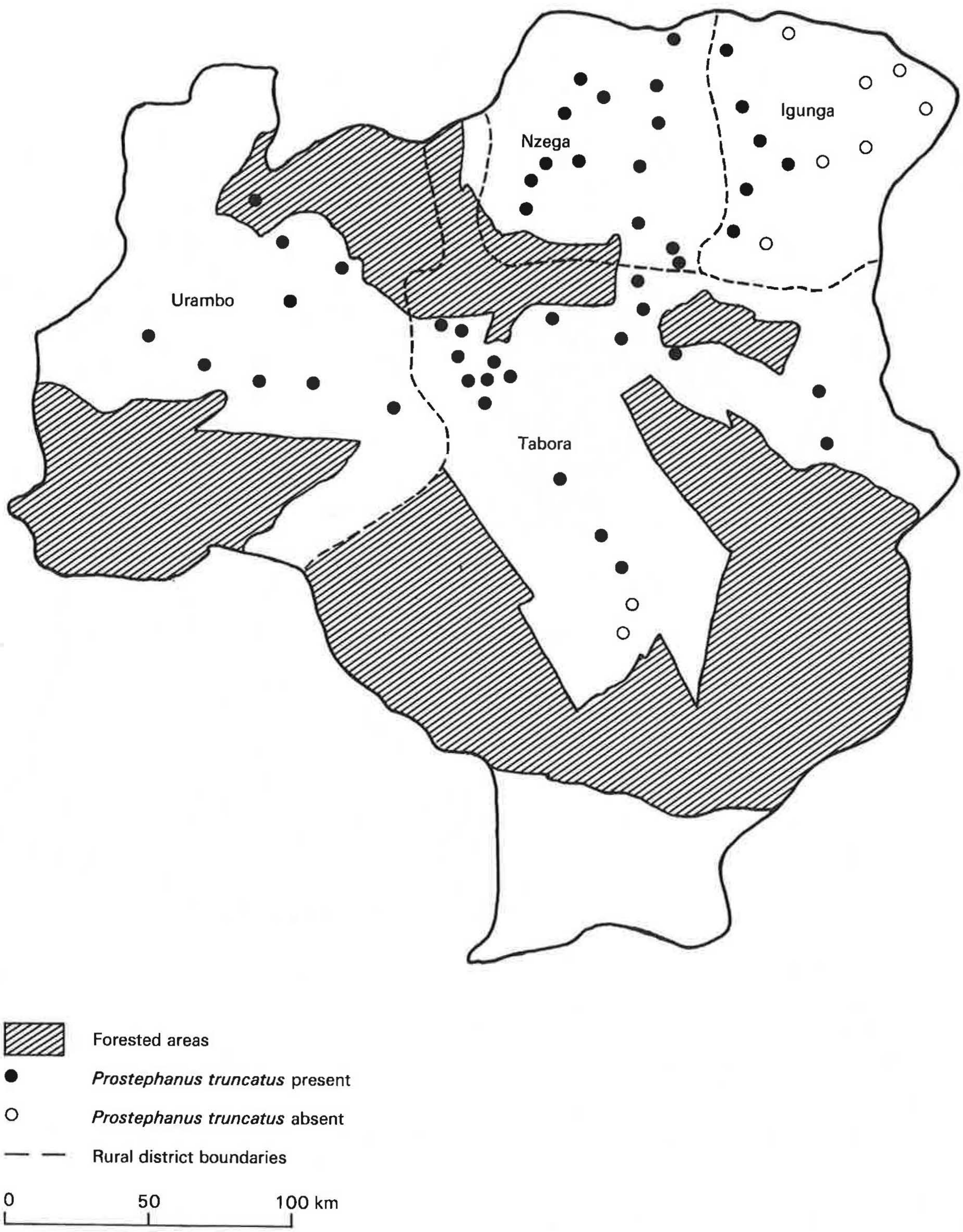
Indicates Tabora region; for details *see* Map II

● *Prostephanus truncatus* present

○ *Prostephanus truncatus* absent

— — Regional boundaries

Map II
Localities in the Tabora region surveyed for *Prostephanus truncatus*



INSECTICIDE TRIALS

Treatment of maize cobs

Farmers store maize on the cob with the husk intact. However, as *P. truncatus* is capable of boring directly through the sheath to reach the maize grain, treatment of undehusked cobs was considered unlikely to prove effective. Consequently a trial was set up to determine whether dilute dust insecticides would effectively prevent infestation if the dust was applied to dehusked cobs. The following insecticides were tested:

	Dosage *(parts per million)*
Pirimiphos methyl	10
Fenitrothion	10
Bromophos	10
Permethrin	5

For details, *see* Appendix IV p.22.

Treatment of maize grain

The control of stored maize insect pests can be achieved more readily if insecticide is admixed with grain rather than by treating cobs; the insecticide, grain and insects are more intimately mixed. It is also known (Howard, personal communication) that *P. truncatus* breeds less successfully on shelled grain than on cob maize; therefore trials were established to assess the effectiveness of various treatments for protecting shelled grain. Although any recommendation involving the storage of grain rather than cobs would involve a great change in traditional practice, some farmers, in attempts to alleviate the infestation problem, were already shelling the cobs and storing grain in sacks.

Three grain trials were set up, two in a wire mesh crib at Tumbi Research Station and one at Massangwe Youth Camp, about 20 kilometres from Tabora. For details, *see* Appendix IV.

STORAGE AND MARKETING PRACTICES IN THE TABORA REGION

The Tabora region is a major crop production area having 90% of its 900,000 population living in rural areas and cultivating some 2,500 km^2 (250,000 ha) of arable land.

Maize is cultivated in most of the region except in the eastern part of the Igunga district. The Tabora and Urambo districts produce more than 80% of the region's maize crop which accounts for approximately 11% of the total Tanzanian yield. More than 90% of the region's sorghum is grown in the Igunga and Nzega districts; in the former district it is the staple diet for many families.

The region is also a very large producer of cassava, this crop being the only one which is produced in regular surplus. Other food crops grown include groundnuts and paddy which account for 30% and 20% of the total Tanzanian production respectively. More than half of the country's flue-cured tobacco is grown in the Tabora and Urambo districts and this is the region's main cash crop.

On-farm storage

As many parts of the region are deficient in maize, crop storage is a vital element of the agricultural practice. There are no co-operative village stores for maize in the region. Most families store undehusked maize inside the house, on platforms (local name 'dari') raised about 2 metres above floor level. The platform is usually constructed in the kitchen area so that the cobs are continually subjected to smoke from the cooking fire. Smoking the cobs is a traditional method of disinfesting the maize of storage insect pests.

In parts of Urambo and Nzega districts maize is stored on wooden frames outside the house ('nkhuli'); the undehusked cobs are arranged in vertical tiers which allow sun-drying after harvest. Often, when the harvest is small, the cobs are placed on the roof of the house to dry and for storage. This maize is generally completely consumed by the onset of the rains.

Most of the other cultivated food crops are stored threshed in sacks, oil drums or in large cylindrical containers ('virindo') constructed from tree bark. In the Igunga district sorghum, which is sometimes stored for up to five years, is kept in cylindrical baskets inside the house ('berere') or outside the house ('kihenge'), which are similar in design and construction to stores found in other parts of Africa. The 'berere' and 'kihenge' can have a capacity of 2 tonnes.

Cassava is lifted from the ground at various intervals throughout the year. Either it is peeled, sliced and soaked in water for 3 days before sun-drying and storing, or it is dried without soaking and covered with grass for several days, when it is then redried and stored. Cassava is stored in sacks, dari or virindo.

Most of the maize of the region is harvested in April and May, at the end of the single rainy season. There is very little damage due to fungal attack in the period immediately after harvest as the weather remains dry. Previously the main insect pests were *Sitophilus* sp. and *Sitotroga cerealella* (Olivier). There are no well-founded estimates of loss maize in farm storage in Tanzania. Cassava was not subject to much insect damage as it is only stored for very short periods before consumption or sale.

Commercial storage

All food commodities sold in Tanzania, with a few exceptions, must be marketed through a central purchasing organisation which has countrywide storage facilities for bagged commodities. In the Tabora region maize is collected and distributed through local godowns and is transported between different districts depending upon local requirements. The Urambo district, in particular, generally provides maize to the Nzega and Igunga districts.

However, it was alleged that significant quantities of grain are marketed outside the central purchasing system to other regions of Tanzania and to some neighbouring countries. In some towns in Tanzania local traders are licensed to sell durable food commodities, including maize and cassava, in local markets. Produce is carried considerable distances from areas producing surpluses to supply these markets. In Mwanza market, for example, maize was found that had been grown in the Kahama district in the Shinyanga region. It is through these trade routes, by road and rail, that *P. truncatus* has reached distant town markets since it is absent from farms in the immediate vicinity of these towns.

The central stores in Tabora act as temporary stores for white maize which is milled locally. As there is a quick turn- round of maize in the store, it is often not fumigated. Other commodities, such as cassava, however, can remain in the depot for several years. These become foci for pest infestation and lead to cross-infestation of incoming, clean commodities.

Pest control

A team of inspectors and pest control operators is based at Tabora. This team is mobile within the region and fumigates produce in local godowns as required.

Fumigations are carried out using phosphine in the form of Detia Ex B plates, Phostoxin tablets and pellets, but methyl bromide is also used. There was no evidence of the use of residual fabric spraying in the Tabora stores, but a residual layer by layer treatment of 5% malathion dust was being used. Inspection of malathion-treated and recently fumigated stocks at Tabora showed no evidence of live insects within the stacks, but live *Sitophilus* sp., *Sitotroga cerealella, Plodia interpunctella* (Hubner) and *Corcyra cephalonica* (Stainton) were found on stack surfaces.

DISCUSSION

The distribution and biology of *P. truncatus* have been reviewed comprehensively in an unpublished paper by Karel and Mhuru (1981) of the University of Tanzania. It will be sufficient for this report to highlight the important aspects of its bionomics.

Compared with other major tropical pests of stored products, *P. truncatus* has a fairly restricted distribution. It is an established pest which occurs in Central America, Brazil and Colombia and in the southern states of the USA, including California. Outside this region interceptions of the pest have been reported in commodities moving through international trade—for example in Israel, Iraq, Thailand and China. However, the beetle failed to become permanently established in any of these countries and until the Tanzanian outbreak there was no recorded incidence of the pest in Africa.

Although it has not been possible to trace precisely when and from where *P. truncatus* was introduced into Tanzania, it must have been imported with grain received from overseas. Thus the pest must have passed through one of the main ports of the country and escaped detection.

Many of the Tabora farmers interviewed had observed significant *P. truncatus* infestations for at least two seasons. However, it has not been possible to determine when the pest was introduced into the region and consequently it is not possible to predict its rate of spread. Clearly the pest is now well established in Tabora and neighbouring regions.

In Central America *P. truncatus* infestations often start in the field before harvest and continue throughout storage, particularly in unshelled maize. There are reports of it infesting various roots and tubers as well as other cereals and cereal products. It has also been reported as attacking wooden structures and utensils.

The optimum conditions for development from egg through to adult are 32°C and at 80% relative humidity (Shires, 1979)*. Above 32°C the rate of development declines and although the development period is protracted, it is capable of developing at temperatures as low as 22°C. The influence of humidity is limited; high humidity is more favourable.

The pest is therefore well adapted to hot humid climates such as the Gulf and Pacific Coasts of Mexico and other coastal areas of Central America. It now appears that it is also well adapted to hot dry environments such as occur in many areas of Tanzania and throughout Eastern and Central Africa. Tabora has a mean monthly maximum temperature between 28.4°C and 32.2°C (28 year average, *see* Appendix V, p.23), throughout the year.

Most maize is harvested by June when the rains cease. The humidity remains low until December when the new rainy season commences. Conditions in Tabora, although not optimal at any particular time of the year, are obviously very conducive to *P. truncatus* development. In the dry season the elevated temperatures are beneficial and when the temperatures fall during the rains the corresponding rise in relative humidity (*see* Appendix V) would stimulate breeding. Clearly, the potential for this pest to establish itself and proliferate in this environment has been fully demonstrated.

* Shires, S.W. (1979) The influence of temperature and humidity on survival, development and adult sex ratio in *Prostephanus truncatus* (Horn). *Journal of Stored Products Research,* **15**, 5–10.

P. truncatus is able to cause extremely heavy damage but it seems rarely to have reached its full potential in Central America. This may be for two reasons. Firstly, in Central America, competition from other stored product pests, especially *Sitophilus* species, undoubtedly limits its population increase. By contrast, in East Africa there was very little evidence of competition from other pests. Thus, at least for much of the storage season, *P. truncatus* is able to breed unimpeded. Secondly, since *P. truncatus* develops much more successfully in cob maize than in shelled grain the method of maize storage on farms in Central America is probably unfavourable for the pest.

In Tabora it is common for maize to be stored on the cob. Consequently, in order to control the pest successfully in Tabora a major change in the traditional storage practice may be required. Farmers should be advised to shell all their grain immediately after harvest and then admix a suitable protective insecticide.

Synthetic insecticides and fumigants will have to be applied in any attempt to eradicate *P. truncatus* from East Africa. Very little information is available concerning the effectiveness of organophosphorus or other compounds against *P. truncatus* although preliminary laboratory trials undertaken at TPI have indicated that the synthetic pyrethroid permethrin applied at a dose of 2.5 parts per million (p.p.m.) will provide good control. Pirimiphos methyl applied to grain at the higher dose of 10 p.p.m. would also probably be satisfactory to control the pest. Experimental work on closely related bostrichid beetles, especially *Rhyzopertha dominica* (F.), also demonstrates the superiority of synthetic pyrethroids against this group.

The experimental trials set up at Tumbi are essentially very preliminary as they were initiated some 3–6 months after the local harvest. Furthermore, supplies of cob maize were limited and much of the maize that was used was already heavily infested with *P. truncatus*. The trials were set up according to scientific practice, as rigorously as the prevailing conditions allowed, but for confirmation they need to be repeated at the beginning of the next storage season and expanded to include alternative control treatments and strategies. The application of pirimiphos methyl to save the remainder of this year's crop has been advocated by the Ministry of Agriculture and is endorsed by the team, but only as a stop-gap measure. It must be stressed that whilst care must always be taken when using insecticides, it is particularly important in the case of this infestation to adhere strictly to the recommended dosage in order to obtain both effective control and to avoid undesirable pesticide residues. Furthermore, correct dosage is essential to avoid the development of pest resistance, which is accelerated by under-dosing.

CONTROL STRATEGY

It is technically feasible to eradicate the beetle from Tanzania: the insecticides and the expertise to undertake a campaign are available. However, economic constraints, including the cost of the insecticides, of transport and of technical manpower, will make total eradication very difficult to achieve. Practically, it may be feasible only to contain the infestation within the areas in which it is now found. However, unless responsible measures are taken immediately, we are gravely concerned that the pest may become established rapidly in other areas of Tanzania and in all countries of East and Central Africa that have similar climatic conditions. It is also possible that the pest could extend further and become established in cooler upland areas of Africa similar to the Central Highlands of Mexico. It is our considered view that there are serious international implications arising from this outbreak which should be of concern to much of the African continent, and for as long as the pest continues to ravage cereals and food commodities at the levels found in this study, every effort should be made for its containment and eradication.

We therefore advocate that all countries within Central and Eastern Africa, with conditions suitable for the development of *P. truncatus*, should begin immediately to survey grain stores and to establish regular monitoring; that when and wherever

P. truncatus is found, proper and effective pest control operations are mounted quickly, together with a comprehensive extension programme capable of reaching all farmers.

National survey and regular monitoring

The most obvious measure for the containment of the pest is to prohibit the movement of all grains from infested areas, or until each consignment has been inspected and fumigated. Quarantine inspections should be instituted at specific points of entry, including any small consignments carried by hand. Any infested consignments should be impounded and fumigated immediately; wherever the beetle is found a quarantine area should be declared and the boundary clearly defined. These measures need to be scrupulously applied and to remain in force until the area is declared free of the pest.

No breach of these measures can be permitted if containment is to be achieved quickly without further spread of the infestation. However, it is very difficult to ensure that all grain movement is thoroughly supervised even with a substantial policing operation by trained inspectors working with police, customs and quarantine officers at check points. It may therefore be more practical to limit these inspections to grain moved by any central purchasing or marketing organisation in order to minimise the wider distribution of the pests and to accept the risk that there will be a limited distribution of the pest through private marketing. A major reliance will then have to be placed on regular monitoring which should be carried out by intensive and extensive surveys by specially trained inspection teams. All infestable commodities on farms, in local markets and in commercial stores should be examined. Any areas considered to be at high risk, especially markets, should be monitored on a regular and frequent basis. Any district in which the beetle is found should be isolated and all movement of grain and infestible produce prohibited until all stores have been inspected and infested produce fumigated. The district will then become a high risk area and should be monitored frequently.

Control at central stores

Infested stocks held in central stores must receive treatment as soon as possible. Fumigation with phosphine or methyl bromide is effective if the correct procedures are observed. All stocks about to be despatched from depots and stores should be inspected for live *P. truncatus* and if any are found the stock must be retained until fumigated successfully. Empty sacks should be fumigated before re-use and infested transport treated with insecticide.

So far *P. truncatus* has not proved to be an important pest in large stores. However, any incidence of the pest in silos or bulk store complexes should give rise to concern.

Control at farm level

Because the beetle breeds much more successfully in maize cobs than in loose grain, it is important for farmers to be advised to shell all their grain before treating it. The application of dilute dust insecticides can then be undertaken using a shovel or similar implement, making sure that the insecticide is thoroughly mixed in with the grain.

Very little work has been carried out on the control of this beetle. It is, however, thought to be difficult to control with conventional organophosphorus compounds as is the lesser grain borer *Rhyzopertha dominica*. Preliminary laboratory investigations at TPI indicate that permethrin applied at 2.5 p.p.m. or pirimiphos methyl applied at 10 p.p.m. give good control in maize grain. If insecticides are not available to the farmer, he should spread the grain out in the sun in a thin layer or, if the grain is clean, he can store it in drums covered with a thick barrier (10cm) of ash or sand. Particular care should be taken to ensure that grains retained for seed do not become infested. Cassava should not be harvested until it is needed for consumption.

Personnel training

The success of any operation aimed to contain and control infestation will depend upon the motivation and skill of the personnel responsible. This responsibility will necessarily fall onto extension services and produce inspectorates. Extension and inspection personel must therefore be fully trained in crop storage techniques and practices including pest recognition to ensure that:

(i) the pest can be recognised,

(ii) inspection and quarantine procedures are understood, and

(iii) the use of control measures can be demonstrated and the techniques are applied effectively.

There is likely to be considerable overlap in the work of the extension services and the produce inspectorate, although the latter should have more of an overseeing role. There would therefore be considerable benefits if both groups were trained together as they will appreciate each others difficulties and gain a broader idea of the problems that occur. As appropriate this training may also be given to farmers, extension services, commodity inspectors, pest control officers and store managers.

FURTHER RESEARCH

To date insufficient information is available about the biology and behaviour of *P. truncatus*. The Tropical Products Institute is involved on further research into this beetle and plans to undertake detailed field investigations of the following:

(i) Population growth as related to time and environmental conditions.

(ii) Host crops attacked, including infestation differences between shelled maize and unshelled maize and levels of loss.

(iii) Field infestation and the movement of *P. truncatus* between field and store.

(iv) Ability of *P. truncatus* to spread from a source of infestation.

(v) Ecological relationships with other pests, i.e. predators, parasites, etc.

With regard to the present need for control measures, recommendations have been produced but they are necessarily based on limited experimental work. We cannot claim that they have proved to be effective in practice. Further work on the development and evaluation of control procedures is therefore urgently required. In particular it would be valuable to assess:

(i) Thermal disinfestation by exposure of dehusked cobs to the sun.

(ii) The conditions under which smoking of cobs in the dari might be effective, e.g. if the husk is removed.

(iii) The efficacy of admixing maize core ash or applying a layer of ash above the grain to act as a barrier against insect penetration. Ash from cooking fires could also be tested.

(iv) The use of a wide range of different synthetic insecticide treatments. Preliminary laboratory tests indicate that whilst some organophosphorus insecticides (e.g. pirimiphos methyl, chlorpirifos methyl) will provide a degree of protection, synthetic pyrethroids (e.g. permethrin) might be more effective. Thus alternative pyrethroids and synergised pyrethrins must be evaluated against other organophosphorus compounds and the optimum dosage rates established.

Appendices

APPENDIX I: IDENTIFICATION OF THE BOSTRICHIDAE WHICH INFEST STORED PRODUCTS

The species of the beetle family Bostrichidae are principally wood borers but some will breed in stored products and are important as pests. The basic form of the adult Bostrichidae, illustrated in Plate III a (*see* p.19), is rather uniform and typical of boring beetles. The body is cylindrical and the head ventral to the prothorax so that it is not visible from above. Characteristically, the pronotum has rasp-like teeth, hooks or horns, the antennae are straight, i.e. not elbowed, and have a loose 3– or 4–segmented club (*see* Plate III a). At the posterior end of the beetle the elytra slope ventrally more or less steeply (this sloping region is called the declivity) and are generally somewhat flattened. The elytral declivity may be marked or decorated with ridges, tubercles or hooks, all of which are useful recognition features. The tarsi are all five-segmented.

Key (for Key to Plate III *see* p.20)

1 Posterior tarsus always shorter than tibia. Anterior region of pronotum with several transverse rows of teeth (*see* Plate III b, d and f). Never with large hooks or horns on the pronotum or elytra. Length 2.5–4.5 mm. (Principally storage species) 2

— Posterior tarsus longer than tibia. Pronotum or elytra frequently decorated with large hooks or horns. Length exceeding 4.5 mm. .... Wood boring species.

2 Posterior regions of pronotum with flattened tubercles (*see* Plate III b); elytral declivity gently convex and elytral hairs arched (*see* Plate III c). Appears as in Plate III a. (Common throughout warm and tropical regions: infesting various commodities especially whole cereals). .... *Rhyzopertha dominica* Fabricius.

— Posterior regions of pronotum without flattened tubercles (*see* Plate III d and f); declivity strongly convex or flattened and steep (*see* Plate III e and g). Elytral hairs all erect or only erect on apical one-third of elytra 3

3 Elytral declivity steeply sloping and without ridges or ornamentation (*see* Plate III e). Posterior region of pronotum usually with two more or less distinct shallow depressions (*see* Plate III d). (Common in tropics; frequently pests of felled bamboo, may occasionally infest maize) .... *Dinoderus* spp.

— Elytral declivity flattened and with pronounced lateral ridges (*see* Plate III h). Posterior region of pronotum *without* two shallow depressions (*see* Plate III f). (Found in South and Central America, Tanzania and possibly elsewhere; locally important pest of maize) *Prostephanus truncatus* (Horn).

Plate I
Prostephanus truncatus (Horn), the greater grain borer, on a damaged maize grain

Plate II
Damage to maize cobs by *Prostephanus truncatus*

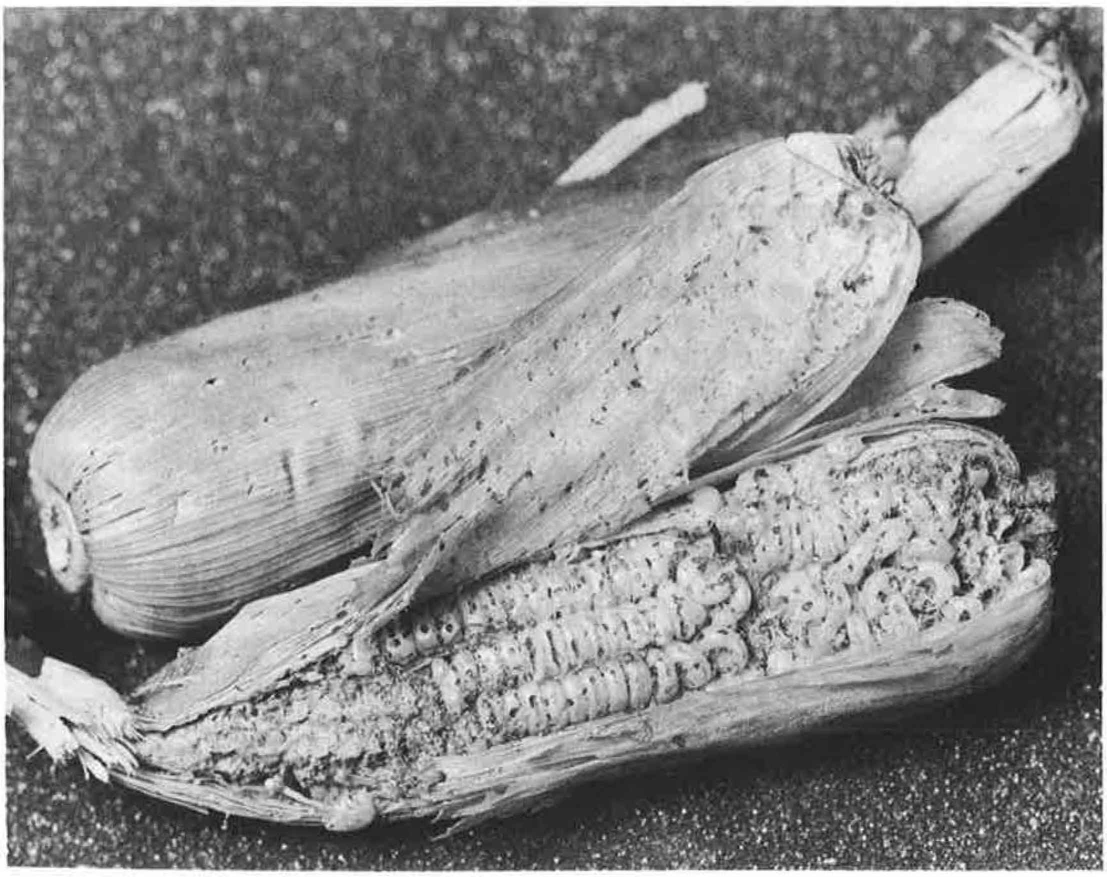


Plate III
Identification features of the Bostrichidae

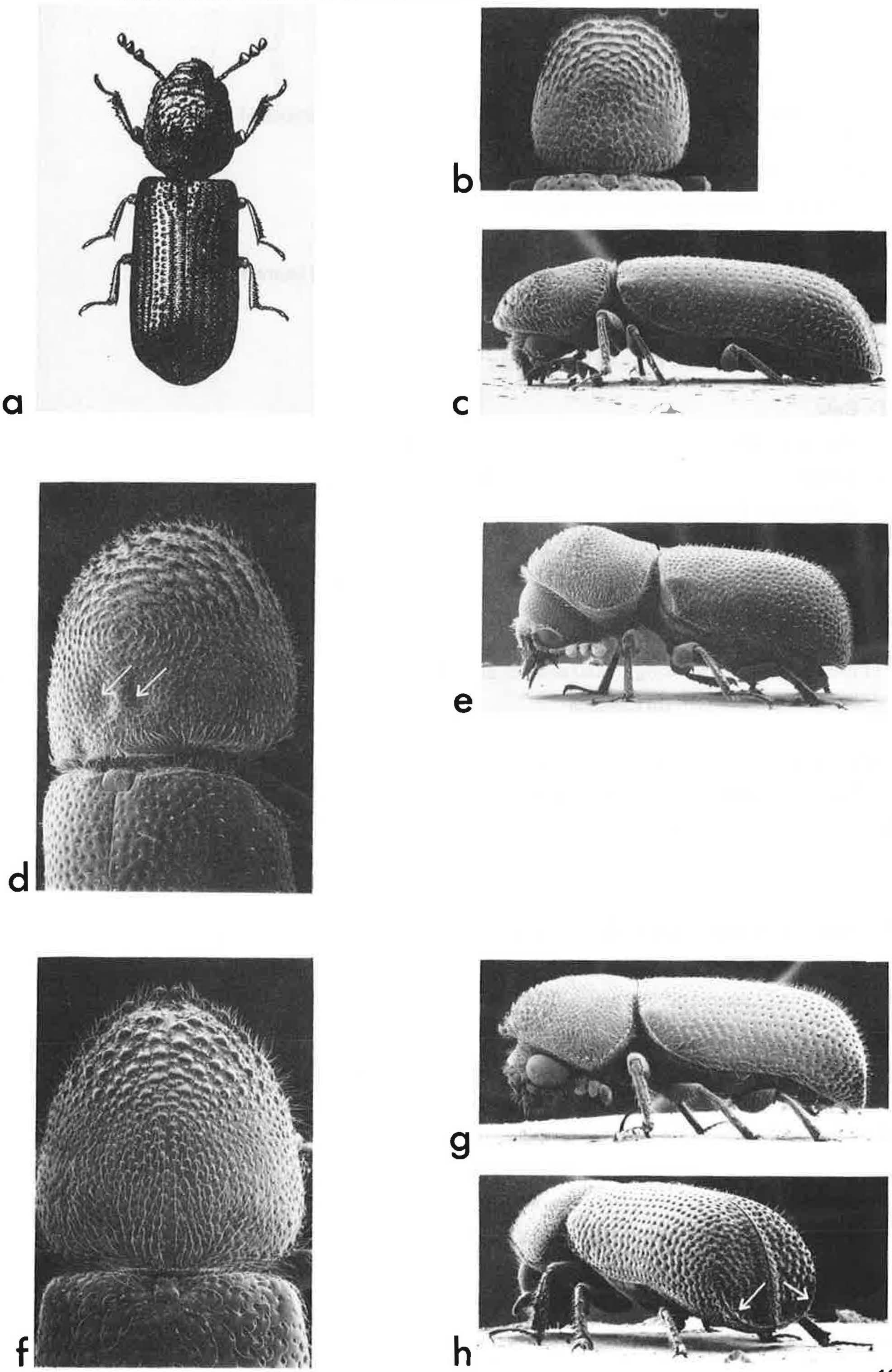


Plate III

a Dorsal view of adult *Rhyzopertha dominica*

b Dorsal view of pronotum of *R. dominica*

c Lateral view of *R. dominica*

d Dorsal view of pronotum of *Dinoderus* sp. (arrows indicate positions of slight depression)

e Lateral view of *Dinoderus* sp.

f Dorsal view of pronotum of *Prostephanus truncatus*

g Lateral view of *P. truncatus*

h Posterior view of *P. truncatus* (arrows indicate the pronounced lateral ridges)

APPENDIX II: FARMER QUESTIONNAIRE

1 Date ....

2 Farmer's name.................. 3 Village..........................

4 District .... 5 Region ....

6 What crops do you grow?..

7 When did you harvest? (a) Maize..............................

(b) Cassava..............................

8 How are you storing? (a) Maize..

....

(Type of structure; smoking; cobs/shelled; sheath/no sheath)

(b) Cassava..

....

(Type of structure; additives; chips/tubers, etc.)

9 What other food crops are you storing?..............................

10 How are you storing them? (a) ....

(b) ....

(c) ....

11 How much maize did you harvest? (a) this year..............................

(b) last year..............................

12 How much cassava did you harvest? (a) this year..............................

(b) last year..............................

13 How much maize did you sell? (a) this year..............................

(b) last year..............................

14 How much cassava did you sell? (a) this year..............................

(b) last year..............................

15 Have you had any problem from *Prostephanus truncatus?*....................

16 What crop(s) has *P. truncatus* damaged? (a) this year..........................

(b) last year..........................

17 How long ago did you notice *P. truncatus* being a pest?......................

18 Did the *P. truncatus* start in the store or in the field?..........................

19 How much maize did you lose because of *P. truncatus* last year? (percentage, fraction, cash, weight) . . . .

20 How much of other crops did you lose last year due to *P. truncatus*? . . . .

. . . .

21 Have you tried to protect your crops from *P. truncatus*? . . . .

22 What did you do? . . . .

23 How much did you use (g/kg; packets/oxcarts)? . . . .

24 How effective was the treatment? . . . .

25 Does your (traditional) method of smoking the maize cobs prevent/stop/inhibit *P. truncatus*? . . . .

26 Do you think *P. truncatus* is an important pest problem? . . . .

27 Have you any comments to make? . . . .
(Did the structure become damaged?)

Headman/Chairman questions

1 How many farmers in your village?

2 How many have reported *P. truncatus* problems?

3 When did *P. truncatus* first become a problem in this village?

4 Had you heard reports of *P. truncatus* in other districts/regions?

APPENDIX III: SAMPLE ANALYSIS. METHOD OF ANALYSIS FOR SAMPLES TAKEN IN THE TABORA REGION

Maize cobs

1 Cobs with *P. truncatus* holes in the sheath were counted.

2 After removing the sheath (if present), cobs with infested grain were counted.

3 The cobs were shelled.

4 Dust and insects were sieved from the grain. The weight of dust and the number and identity of insects were recorded.

5 The moisture content of each sample was measured three times.

6 The standard volume weight of each sample was measured three times. This technique is one method of determining losses due to insect damage.*

7 The sample was coned and quartered twice. Using two of the remaining quarters (each approximately 200 g) the loss due to insect damage was estimated by another technique, counting and weighing.*

Shelled maize

When the sample of maize donated by a farmer was already shelled, analysis began at 4 above.

* Methods described in *Post-harvest grain loss assessment methods* (1978) edited by K. L. Harris and C. J. Lindblad and published by the American Association of Cereal Chemists, Washington, D.C., 193pp.

APPENDIX IV: INSECTICIDE TRIALS

Trial with maize cobs

The trial was set up at Tumbi Research Station, near Tabora, in a large wire mesh crib, the base of which was raised off the ground to a height of almost one metre. The trial was of a randomized design. Each block represented one of the following insecticide treatments:

Pirimiphos methyl	10p.p.m.
Fenitrothion	10p.p.m.
Bromophos	10p.p.m.
Permethrin	5p.p.m.
Control	(untreated)

Chicken wire was used to separate blocks and also to divide each into 12 compartments, each of which contained 6.5 kg of dehusked cob maize equivalent to approximately 5 kg of grain. Four compartments (replicates) in each block are to be sampled at two-monthly intervals for six months. Cobs inspected in villages in the Tumbi area were found to be heavily infested with *P. truncatus* so that the trial was established in an area having a heavy infestation pressure.

Three of the dusts, 2% pirimphos methyl ('Actellic'; Twiga), 2% fenitrothion (Twiga) and 2% bromophos ('Nexion'; Ciba-Geigy), were obtained in Tanzania. Permethrin (0.5%) was obtained in the United Kingdom from the Wellcome Foundation Ltd. Cobs for this trial were obtained from Tabora and Urambo districts. As the trial began several months after the storage season had commenced, many of the cobs were heavily damaged by *P. truncatus*, particularly those obtained close to the research station. All the cobs were heaped and mixed before replicates were selected haphazardly from the heap. Twenty replicates were removed as initial samples, fumigated with phosphine at Tabora central stores and sent to the United Kingdom (TPI) for analysis.

Trials with shelled grain

(i) Tumbi trials:

(a) Forty-five small, open-topped plastic containers were filled with 1.5 kg of 'local' maize grain. Each group of nine containers was subjected to one of the following treatments:

(i) 2% pirimiphos methyl dust applied at 10p.p.m.

(ii) Ash obtained from burnt maize cobs applied at 30% by weight.

(iii) As for (ii) but application at 10% by weight.

(iv) Maize core ash applied as a 2.5 cm layer above the grain.

(v) Control (untreated).

The first three treatments were admixed by hand. The replicates were laid out at random.

Three replicate containers are to be sampled at two-monthly intervals for six months. Three replicates were selected as initial samples and fumigated before analysis.

(b) An 800 g sample of 'local' maize obtained from a well mixed heap were put into 1 litre glass beakers. Each was treated with one of the following insecticide applications:

(i) 2% pirimiphos methyl dust at 10p.p.m.

(ii) 2% fenitrothion dust at 10p.p.m.

(iii) 2% bromophos dust at 10p.p.m.

(iv) 0.5% permethrin dust at 5p.p.m.

There are three replicate beakers for each of the three sampling occasions as well as a series of untreated controls. The replicates were laid out at random in the crib.
The grain used in the two trials was free of infestation. However it was subject to heavy infestation pressure from the cob trial and from the villages surrounding the research station where *P. truncatus* damage was very extensive.

(ii) Masangwe trial

Eighteen bags of local maize were each divided in half and each half (45 kg approximately) was treated as follows:

(i) 2% pirimiphos methyl at 10p.p.m., or
(ii) 0.5% permethrin at 5p.p.m., or
(iii) left untreated.

Four replicates were set up for each of the three two-monthly sampling intervals. The treatments were laid out in discrete blocks, the replicates within blocks arranged randomly. The maize used for this trial was infested with *Sitophilus* sp. and *S. cerealella*. Although *P. truncatus* were observed in a nearby store which had housed the newly harvested cobs, none were found in the grain. Each treatment block, therefore was seeded with approximately 100 *P. truncatus* by sprinkling adults over the surfaces of the bags and between bags.

APPENDIX V: CLIMATIC AVERAGES AT TABORA AIRPORT (28 years to 1979)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum temperature	28.4	28.5	28.8	28.5	28.8	28.9	28.9	30.1	31.4	32.3	30.5	28.3
Minimum temperature	17.3	17.3	17.2	17.0	15.6	13.7	13.7	15.6	17.5	18.7	18.4	17.7
Relative humidity 09.00 h	83	84	83	81	73	65	61	57	54	55	66	79
Relative humidity 15.00 h	54	55	55	55	45	37	33	31	30	30	42	55
Rainfall (mm)	114.9	136.6	137.3	120.1	27.0	0.0	0.3	0.2	3.6	20.2	98.5	173.7

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