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GUEST EDITORIAL

Stored-Product Entomology— The Challenge of the Next Decade

Peter F. Prevett
Overseas Development Natural Resources Institute
Storage Department, London Road, Slough, Berks SL3 7HL

It is fitting that this, first, Guest Editorial to the new-format Bulletin should be devoted to stored-product entomology since 1990 celebrates 50 years of the formal establishment of stored-product insect research and control programmes in Britain. It was in 1940 that the Pest Infestation Laboratory was established at Slough under the, then, Department of Scientific and Industrial Research, consolidating the work begun some 15 years earlier under Professor J. W. Munro in the Entomology Department of Imperial College; almost at the same time, the Infestation Control Division of the Ministry of Food (now MAFF) was set up as an inspectorial and advisory body. Much has been achieved and many organisational changes have taken place since then. The original organisations have come together under the umbrella of the Ministry of Agriculture, Fisheries and Food (MAFF) whilst the group which was initiated at Slough in 1951 to address problems of storage in tropical areas is now the Storage Department of the Overseas Development Natural Resources Institute (ODNRI), the scientific unit of the Overseas Development Administration, UK (ODA). Slough has become synonymous with stored product research in Britain and beyond; sadly, however, the 'Slough connection' is destined to end—the ODNRI department will move this year to join its sister departments in the institute's new major laboratory development at Chatham, Kent, whilst plans are in hand for the eventual relocation of the MAFF laboratory as part of the Central Science Laboratory of the Agricultural Development and Advisory Service (ADAS).

Whilst this editorial is concerned with stored-product entomology, it is important to recognise that entomology is but one of a number of disciplines which combine and interact within 'storage technology'. In contrast to pre-harvest applied entomologists, the stored-product entomologists usually find themselves working as part of a multidisciplinary team addressing the complex of problems which affect the quality of grain and similar products as they move through the post-harvest (or post-production) system. Although biological organisms, particularly insects, are the primary causative agents of quantitative and qualitative loss during storage, the solution to this problem is not simply one of controlling or 'managing' pests but of considering also the physical and engineering factors which combine to create the storage environment within which they may develop. Thus, a potential tool in the IPM armoury against storage pests, which is not available to the field crop entomologist, is the manipulation of that environment in such a way as to create conditions unfavourable for population increase.

One must also recognise the importance of pre-storage factors such as harvesting and threshing methods and, particularly, drying, in determining the susceptibility of grain to deterioration during storage. For example, the susceptibility of rice to infestation may be greatly increased as a result of harvesting by combine, compared with traditional methods, because of mechanical damage to the husk which creates an ideal environment for the development of *Rhyzopertha dominica* (F.) (Bostrichidae). Similarly, rice which has been parboiled is highly susceptible to infestation by *R. dominica* because the parboiling process leaves the glumes partially open and provides a ready means of entry for the first instar larvae of this species. I recall a major problem of *R. dominica* infestation of parboiled rice in a West African country some years ago which arose not because of control difficulties but because rice mill parboiling capacity was allowed to outstrip milling capacity to such an extent that large quantities of dried parboiled rice were stored for long periods before they could be milled—an excellent example of a storage pest problem which could have been largely avoided through proper commodity management (as distinct from 'pest management' alone).

By the same token, one of the commonest causes of pest population build-up in stores at all levels of operation from the subsistence farmer to the large government parastatal is a failure to observe the basic principles of good storage management in the sense of orderly rotation of stocks and good storage hygiene. I have long held the view that the most important items of pest control equipment for use against storage pests are the broom and dustpan and brush. I remain convinced that if these were used regularly and effectively by those responsible for stored grain at all points within the marketing system, we would witness a dramatic reduction in post-harvest losses.

Instead, there has been over-dependence on contact insecticides and fumigants, frequently applied on a 'calendar' basis without any attempt to assess either the magnitude or nature of an infestation; frequently applied also without due regard to correct application rates or procedures. Is it surprising that we are now seriously concerned about resistance to both contact insecticides and fumigants? The problem is not new. Twenty five years ago Parkin (1965) wrote 'we are therefore now faced with a serious threat to the future use of pyrethrins, lindane and malathion in several parts of the world where they have hitherto been regularly and extensively applied'. Yet it was only ten years earlier (Parkin, 1955) that he had warned 'we must be on the watch for the development of resistant strains of stored-product insects. *None of real significance has yet appeared and some workers consider that they are not likely to do so*, but I think that some species will eventually be able to find suitable conditions in warehouses etc., to evoke any potentiality towards high resistance. Let us hope that no such potentiality exists'.

The standard response when resistance occurs has been to seek alternative compounds to replace those which are no longer effective. However, there is now increasing concern about the discovery in a number of developing countries of strains of stored-product insects, notably *R. dominica* and *Tribolium castaneum* (Herbst) (Tenebrionidae), showing resistance to phosphine. Since it is most unlikely that an alternative fumigant possessing the same characteristics of effectiveness and ease of application will become available in the near future to replace phosphine, it is essential that appropriate corrective action be initiated before it is too late. It is the very ease of application of phosphine which has led to a casual approach to its use when compared with other fumigants such as methyl bromide, with the result that treatments are frequently carried out under inadequately gas-tight conditions and for exposure periods which do not meet minimum requirements for effective control. There is an urgent need for training and for routine monitoring programmes to be established, not only to determine the resistance status of local strains of storage pests but also to minimise the possibility of movement of resistant strains between countries through international trade.

Reference to the spread of insect pests through international trade automatically brings to mind the *bête noir* of the stored-product entomologist—the Khapra beetle *Trogoderma granarium* Everts (Dermestidae)—and I make no apology for being tempted again to quote the words of Parkin (1956) in this context—'The fact that the front of knowledge in stored product entomology is steadily advancing *must not lead to complacency. The insects are still firmly entrenched in many of their strongholds and can still effect sorties and surprises*, as witness the recent appearance in California and the neighbouring States of *Trogoderma granarium* Everts . . . . .'. Who among us would have predicted ten years ago that a new *bête noir*, *Prostephanus truncatus* (Horn) (Bostrichidae) the Central American cousin of the cosmopolitan *R. dominica*, was poised to 'effect sorties and surprises' and take centre stage in the storage arena? Not Freeman (1977), who made no mention of *P. truncatus* in his paper on prediction of new storage pest problems though, in fairness to him, there was at that time little published information on the biology of this species on which to base such a prediction.

Prostephanus truncatus is now established as a major pest of farm-stored maize and dried cassava in six African countries and is seen by many as a potential threat to maize production in Africa. A measure of the attention which has been given to this species since it was first recognised in Tanzania in 1981 is seen in the number of research citations—I have noted a total of only 16 up to 1981 and 50 from 1982 onward! Whilst one is concerned at the implications of this invasion, the entomologist within must admit to a feeling of excitement for what may lie ahead. For what is remarkable is not only that it took so long for man (by whatever means) to transport a pest of such significance from one side of the world to another, but that this act has provided us with the first potential opportunity for classical biological control of a stored-product pest! In Central America, the predatory histerid *Teretriosoma nigrescens* (Lewis) is associated with *Prostephanus* and there are strong indications from field and laboratory studies that this predator is host-specific. More research remains to be done in order to understand fully the ecological relationship between predator and prey before its possible inclusion in integrated control programmes for Africa. We need also to examine broadly the range of climatic, agronomic and social factors which operate in Central America to maintain pest populations at levels which result only occasionally in serious loss, compared to the African experience. It would be foolish to assume that this is solely the effect of biological control influences.

Another example of a new pest problem which demands the attention of the researcher is seen in the change in status of Psocoptera in recent years. This has occurred in Britain in relation to the greatly increased stocks of dried skimmed milk held in store subsequent to our entry into the European Economic Community (EEC) (Freeman, 1977) and in certain tropical countries where populations of liposcelids have been observed to reach epidemic proportions apparently as a result of current pest control procedures. We find that we know very little about the ecology, damage potential or susceptibility to control chemicals of these insects, which were hitherto regarded merely as scavengers in damp, unhygienic situations.

This is not the case for the majority of stored-product pests—for most of these we have amassed a vast body of data on biology, behaviour, physical limits and susceptibility to contact insecticides and fumigants. Much of this information, however, is derived from laboratory studies whereby a picture is built up from experiments undertaken at various combinations of constant temperature and relative humidity. The ease with which such work can be done with storage pests is sometimes seen as advantageous in comparison with the difficulties often faced by the field crop entomologist. However, if we are honest with ourselves we might admit that, in building up our picture in this manner, we have taken the easy way, ignoring the real world of the bulk of grain or the bag-stack in which insect infestation, usually of more than one species in competition, progresses within an environment of temperature and relative humidity gradients influenced by ambient changes, the type of storage building and the relationship between the particular commodity and its environment.

We should be concerned about the inadequacy of the resources available to those responsible for inspection of stored produce. These are essentially limited to visual inspection for insects upon the fabric of the warehouse and the surfaces of bag-stacks and the detection of insects within stacks by simple spear sampling of peripheral bags. The sheer impossibility of this task is perhaps a major reason why the 'calendar' approach to pest control in stores, whereby contact insecticides are sprayed, or fumigations carried out, at regularly defined intervals regardless of proper assessment, is so prevalent. Despite our wealth of knowledge of the pests and their biology, we are only now beginning to address the need for improved procedures for monitoring pest populations and interpretation of the results obtained. To the overseas researcher who is anxious to make a real contribution I would say 'leave your laboratory and go into the store, young man'. There is an urgent need for more 'field' ecological studies of interacting communities of stored-product insects within bag-stacks and bulks of grain, in relation to the physical environment, if we are to achieve the level of understanding required to develop effective approaches to pest management.

In offering the challenge for more research of this type it is disappointing to find oneself echoing words written 35 years ago—'more detailed scientific measurement is required of the numbers and distribution of insect populations in goods and premises . . . .' (Parkin, 1955). I trust that they will not need to be repeated again. Or will biotechnology proceed at such a pace in progressing our work to develop plants which are resistant to insect attack that such effort will become redundant?

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Correspondence relating to this article should be addressed to the Editors.