# A GLOBAL VIEW OF ARTHROPOD PEST STATUS IN RELATION TO CHANGING STORAGE AND MARKETING PRACTICE

J.A. Conway

*Tropical Development and Research Institute, Slough, UK*

## Introduction

The status of arthropod storage pests is influenced by many factors, but it has always been particularly and strongly influenced by prevailing storage and marketing practices. Changes in these practices, whether slight or fundamental, may lead to quite dramatic effects in terms of the infestation potential of a stored commodity and of the pest spectrum which may exploit the new situation. In support of this fact one may cite the United Kingdom experience where, in a very few years, the status of the saw-toothed grain beetle Oryzaephilus surinamensis (Linnaeus) was raised from that of exotic tropical import to that of the United Kingdom's number one endemic grain pest. This followed the widespread adoption of combine harvesting which led to significant levels of mechanical damage, allied with mechanical drying and the bulk storage of grain at temperatures considerably higher than ambient.

The success or failure of a pest species to maintain its pest status may also be heavily dependent upon the physical form in which the commodity is stored. Groundnuts held in shell for many months in Sene-Gambia may be devastated by Caryedon serratus (Olivier), the groundnut seed beetle, whereas the same commodity held in decorticated form in Nigeria is not attacked by C. serratus, although the species is present, but the split and broken kernels may be heavily damaged by Tribolium castaneum (Herbst).

In the rice-based economies of South and South-East Asia, a change in storage practice relating to the holding patterns of unhusked rice or paddy versus milled rice can lead to a marked change in status of the insect pest complex. Paddy in storage is much less susceptible to insect infestation than milled rice but in commercial operations the economic benefits to be gained from shipping and storage of milled rice, which occupies one-quarter less space than paddy, are often compelling.

Whilst many countries may go through periods of little change in terms of storage practice, it is rarely, if ever, true that marketing systems remain static. It could be argued that a period of quite dynamic change is presently upon us in several parts of the world both in terms of storage and marketing practices. We might do well to reflect on past experiences in an attempt to foresee and possibly forestall changes in arthropod pest status which could have serious economic implications for the countries concerned.



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## Review of some recent and perceivable changes in storage and marketing practices

### Far East/Australia

In Australia, it seems certain that there will be significant increases in the medium-long term storage of bulk wheat in phosphine-fumigated bunker systems as well as in the large scale and widespread adoption of controlled atmosphere storage. Efficient control of Rhyzopertha dominica (Fabricius) by phosphine or $CO_2$-rich atmospheres could lead to a decline in the status of this pest and reduced reliance on contact insecticides to many of which R. dominica has a high natural tolerance.

In China, the continued development of sealed storage systems in the rice industry and extension of these techniques to maize, wheat and pulse crops could be expected to lead to a general decline in the significance of storage species. The introduction of both skin-packs utilising polyethylene film and PVC sheet covers for bag stacks should prevent access by insect pests to a considerable degree.

### S.E. Asia

Burma appears determined to regain its former market position by re-vitalising its rice export industry. Although having an unenviable reputation for exporting insect infestation in the past, competition from other rice exporters in the region is leading to improved quality levels including stricter infestation controls, and therefore the earlier situation is unlikely to recur. Although the previous trade in animal feed ingredients to Europe from Burma has been largely replaced by commodities from other sources, there is a considerable intra-regional traffic in these animal feed commodities and dissemination of economically important pests could well be occurring. For example, it would be interesting to speculate on the origin of recent Trogoderma granarium Everts infestations in Malaysia.

Indonesia, formerly a significant importer of rice, is now self-sufficient and moving into the status of net exporter. In this surplus situation, with a policy of expanding rice milling capability, storage periods are likely to lengthen and the ratio of milled rice to paddy stored will increase. We can expect the status of Sitotroga cerealella (Olivier), Rhyzopertha dominica and Sitophilus oryzae (Linnaeus) to decrease in this situation, and the status of the milled rice pests, Corcyra cephalonica (Stainton), T. castaneum, Sitophilus zeamais Motschulsky, Psocoptera, and other secondary pests to be enhanced.

Controlled atmosphere storage using $CO_2$ under gas-proof sheets and vacuum-packing of one-tonne lots of milled rice are also being introduced at central storage level in Indonesia and can be expected, in due course, to influence the storage pest situation if large-scale adoption of these techniques continues.

The commercial significance of the common Psocoptera, although their pest status remains incompletely defined, could assume greater prominence in longer term storage of milled rice where higher quality demands of consumers are already posing problems for marketing agencies. It has been suggested that the prevalence of Liposcelis entomophilus (Enderlein) may be linked to the suppression of predatory cheyletid mites by routine pesticide applications (Haines and Pranata, 1982).

It is interesting to note the recent report of the re-emergence of T. granarium as a major pest of the rice industry in Malaysia to the extent that a national committee has been formed to coordinate control measures (Rahim, 1985). This phenomenon appears to cast some doubt on the theory that the successful establishment of this species as a significant pest is restricted to areas of low ambient relative humidities (Banks, 1977).

In the ASEAN region, clear correlations between storage practice and pest status have been observed and commented upon. S. oryzae appears to predominate on paddy, with R. dominica also prominent at farm level. S. zeamais has attained dominance on both milled rice and maize in most countries of the region (Semple, 1985). Strains of S. oryzae exhibiting a preference for certain pulses, e.g. green gram, which recent work suggests may have a genetic basis, could conceivably prelude the emergence of a new pest problem in pulses.

There are signs that the moth Plodia interpunctella (Hubner) is declining in importance in the ASEAN region although reasons for this have not been proposed (Semple, op. cit.).

South Asia

The present substantial evidence of widespread phosphine resistance in this area has led to concern over the possibility of the spread of resistant strains in exports from India and Pakistan. The status of C. cephalonica has been enhanced in the region due to infested exports of raw rice from Pakistan to Bangladesh and Sri Lanka whilst recent reports from India indicate a possibly enhanced pest status for this moth.

T. granarium continues to be a major pest in the wheat-growing areas of Pakistan and India and is likely to remain so for a considerable time given the entrenched nature of farm-level infestation.

Lengthening storage periods for imported wheat within the central food system in Bangladesh in recent years, coupled with the entry into the system of increasing amounts of home-grown wheat, has led to the emergence of R. dominica as the most important pest species. The effectiveness of the prophylactic insecticide combinations used in Australia on wheat exported to Bangladesh has certainly played a part in suppressing the development of S. oryzae, formerly the major pest at central storage level. The development of significant resistance to phosphine in R. dominica in both Bangladesh and Nepal allied with a

continued expansion of wheat growing in those countries would suggest that the status of this species could rise still further. The possibility of T. granarium extending its range into these areas is unlikely due to unfavourable climatic conditions for the species but the recent experiences in Malaysia with this species should be borne in mind.

In Pakistan, some change to bulk storage of wheat in locally made concrete silos is taking place at national food grain agency level, although most stocks are still held in conventional godowns. Holding patterns are also changing with imported soft white wheat, intended for transit to the refugee camps in the north, displacing indigenously-produced harder wheats in parts of the central storage system. This could produce more favourable conditions for serious R. dominica infestations.

A decline in the status of T. castaneum in the wheat flour industry of Sri Lanka is taking place following a change to importation of raw wheat instead of milled flour, the commissioning of new roller mills, and a rationalised milling and storage system related to offtake demand. The short storage periods being introduced for milled flour effectively prevent the development of the heavy T. castaneum infestations which were formerly a feature of this industry (Friendship, 1984).

In the more humid zones, greater attention is likely to be focused on heavy psocid infestations on milled rice with the continued expansion of large-scale centralised storage. There is some evidence that the rapid build-up of psocid populations is more marked in systems where regular chemical control measures are carried out.

West Africa

The discovery of established infestations of Prostephanus truncatus (Horn) in Togo and subsequently in Benin has introduced a new dimension to pest problems at farm level in this region. A major GTZ-assisted programme aimed at containing the spread of this species is presently underway. In the Sahelian zone T. granarium persists as a major pest although replacement of traditional storage buildings with purpose-built conventional stores at centralised level could lead to a reduction in harbourage for the species at this level. Any meaningful decline in status of this species, however, will be contingent upon recently-introduced improved standards of storage and pest management practices being maintained. The significance of S. oryzae has increased commensurate with the substitution of home-grown sorghum and millet by imported rice which is often initially at a higher moisture content than local stocks. Conversely, it has been suggested that attempts to distribute local surpluses of the preferred white sorghum varieties to other deficit countries within the region may have led to the dispersal of phosphine-resistant R. dominica strains.

The status of the major pest species may have declined somewhat in the Sahelian zone due to the increased technical efficiency of the central marketing organizations operating in near-monopolistic conditions caused by acute deficits. However, a return to a situation of significant marketable surpluses of locally-produced grains will bring private traders back into the equation with predictable consequences for pest infestation and dispersal.

At farm level throughout the region the initiatives being taken to increase self-sufficiency by promoting greater production of cereals and pulses will, in many cases, entail the replacement of traditional varieties with higher yielding hybrids. Storage practices which proved adequate for the conservation of traditional varieties may be less satisfactory for newer varieties and hybrids which are often more susceptible to attack by storage insects. A re-examination of our capability to introduce cost-effective loss reduction techniques at this level may well be called for.

Central Africa

It has been noted that plans to boost sorghum production, e.g. in Central African Republic, will create marketable surpluses in amounts which will extend the present dry-season storage into the rainy season. Serious pest problems have not previously been encountered with sorghum held at very low moisture levels but this situation could change as moisture uptake occurs.

East Africa

P. truncatus is known to be distributed over much of Tanzania, and has spread to Burundi and southern Kenya (Hodges, 1986). TDRI, under the auspices of FAO, is currently assisting the Tanzanian Government in a chemical control, monitoring and training programme and both TDRI and GTZ are investigating biological control possibilities for this species. It seems inevitable that P. truncatus will spread further into maize and cassava growing areas of this region and beyond even though the insect may be reduced to low pest status in those areas where control programmes are maintained.

In Zambia, a major change in storage practice for maize held at central level has been a move away from large scale outdoor bagged-grain stacks towards the increased use of new conventional warehousing in sheet-metal-clad buildings. The microclimatic changes thereby induced produce a storage environment which is highly suitable for the rapid development of the moth species P. interpunctella and Ephestia cautella (Walker) as well as for the ubiquitous T. castaneum which was formerly the only rapidly reinfesting pest species of note in the outdoor situation following fumigation against the primary pests.

## Central America

The quite widespread adoption of the use of metal silos at farm level in some parts of the region and the availability of phosphine-generating fumigant preparations has led to a change in the holding pattern for on-farm stocks in several countries. Longer storage periods and the risks of ineffective fumigation have combined to increase the frequency of serious insect infestations developing at farm level. The change from cob storage of maize to bulk storage of shelled grain will have some predictable effects on the insect spectrum and hence the status of individual species. Although P. truncatus has not achieved the pest status on cob maize in this region which it has rapidly attained in East Africa, and recent work in Honduras has suggested that adoption of metal silos would reduce losses caused by insect attack (Hoppe, 1986), TDRI workers have shown that P. truncatus has the ability to develop in well stabilised bulk grain. The field significance of this laboratory finding and the extent to which P. truncatus would be inhibited in competition with S. zeamais in bulk stored maize remains speculative.

## North America

Reports in the pest control literature in recent years concerning infestation of T. granarium in several states of the USA may possibly indicate that this pest may have regained a foothold, however tenuous, in the continent. Perhaps some of our American colleagues present may be able to clarify this situation for us.

One somewhat controversial issue which has arisen from the pioneering work on the use of phosphine for the fumigation of large tonnages of export grain in bulk tankers leaving the USA has been the decision to issue phytosanitary certificates attesting to freedom from living infestation prior to the fumigation process being completed. This is felt to be a necessary procedure as the fumigation takes place while the ship is on the high seas. Actual freedom from living infestation is, of course, dependent upon the contractor carrying out the treatment to a level of efficiency which has been shown to be adequate for disinfestation. As contractual disputes involving insect infestation in grain shipped from the USA to third-world markets are known to have occurred in recent years, one might be excused from questioning whether the issue of phytosanitary certificates as described above might not contribute to a devaluation of the USDA credibility in this area of certification. Any factors which may compound the difficulties of agencies in third-world countries in coping with their indigeneous pest problems, e.g. the importation of insecticide-resistant strains, will naturally be of major concern to those countries and may well induce changes in pest status.

## Europe

The proliferation of intervention storage in which large tonnages of bulk grain are held by member countries under the EEC Common Agricultural Policy represents a marked change in storage and marketing

practices. In the U.K., recent record harvests have pressed into service many storage buildings which are not purpose-built grain stores and which vary widely in their suitability for this purpose. Both government-owned and private sector storage buildings are involved in this operation. The significance of this relatively new component of centralised storage, in terms of its potential for harbouring and disseminating arthropod pest species, can be deduced from the fact that a recent series of routine inspections of government stores found some 43% of them to be infested by common grain pest species. The private sector storage operators in the U.K., almost without exception, practice prophylatic treatment on intake whereas the government sector does not.

The apparent pest status of the fungal feeders Typhaea stercorea (Linnaeus) and Ahasverus advena (Waltl) has been enhanced due to their frequent detection on grain submitted for intervention storage. Such grain is often rejected for 'infestation' by the more cautious but less knowledgeable storage managers, on the mistaken assumption that these species are important storage pests.

O. surinamensis remains 'public enemy number one' in grain storage at farm, merchant sector and centralised storage levels but, interestingly, R. dominica has featured recently in some heavy infestation of wheat and barley.

Although storage practice per se has not materially changed in the U.K. in recent years, the scale of operations has increased dramatically, with 100,000 tonne bulks of grain no longer a rarity. The use of chemical prophylactics at farm and merchant level has also greatly increased in the knowledge that a serious infestation in such large bulks can be disastrous.

In a recent case, disinfestation and related charges amounted to $100,000. Indications are that, with the demolition of old maltings, T. granarium has lost its foothold in the U.K. and, though to a lesser extent, the changes which containerisation and dock modernisation have brought about have reduced the storage habitat for the moth Ephestia elutella (Hubner). This species does, however, occasionally occur on bulk stored cereals.

Although thought to be African in origin, Tribolium destructor Uyttenboogaart has been established in northern Europe for many years but only recently has been reported to be extending its range into the pet food and household sectors in Denmark. As the cold-hardiness of this species is well documented in Canada, there would appear to be scope for further spread within northern Europe and Scandinavia.

With the expansion of container handling facilities in Europe generally, and an ending of the official comprehensive inspection of imported commodities on entry into the U.K., changes in pest status in that country are no longer so readily identifiable. There does,

however, appear to have been an increase in the incidence of C. cephalonica featuring in infestations on imported goods. To date in the current year, this species was present in 60% of the cases in which containers were found to contain insect infestations, and in 25% of all cases of infested commodities in conventional cargoes.

## Conclusions

The above selective summary of some perceived and projected changes in arthropod pest status, many of which can be seen to relate to accompanying changes in storage or marketing practice, would seem to support the contention that challenges abound for the storage entomologist and appear more than likely to do so in the future.

From a global viewpoint, the wheel appears to have turned half-circle from a situation in which the developed nations were the unwilling recipients of tropical pest species on a wide range of imported commodities. Today's new exporters ship large amounts of aid cereals and processed foodstuffs from the temperate and sub-tropical areas of the Americas, Europe and Australia to the deficit countries of the third world. The U.K., for example, exported roughly eight million tonnes of wheat and barley in 1984/5, excluding a substantial tonnage shipped under EEC aid programmes to developing countries.

Although not, perhaps, a common occurrence, shipments infested with cosmopolitan pest species, including some possibly resistant strains, have been included in this export trade and have served to compound the pest problems of some developing countries.

The success with which genera such as Tribolium, Rhyzopertha, Oryzaephilus and Cryptolestes have been able to exploit their natural tolerances to a range of pesticides and/or have rapidly developed resistance mechanisms in order to combat the more effective ones has been a significant development of recent times. No less significant, one could argue, has been the response to this situation which has seen both the evaluation and commercial adoption of the concept of controlled atmosphere storage in Australia in a remarkably short period of time. We see here a rather dramatic illustra- tion of the converse of the general trend in which a fundamental change in storage practice has been deliberately introduced in order to reverse the enhanced status of major pest species.

Who can be bold enough to foresee whether a similar move away from the use of pesticides in response to evolving resistance and towards the use of other physical or biological approaches may not make equally significant inroads into the global arthropod pest spectrum over the next few years ?

The largest single challenge we may have to face as storage specialists could well be the need to evolve a set of conservation strategies designed to cope with the medium-long term storage of surpluses or food security stocks in unfavourable tropical conditions. Prevailing conditions may well dictate that our pest management regime for such an eventuality will perforce include a much smaller chemical control component than would have been thought possible only ten or so years ago.

Whereas the recent past has witnessed a considerable concentration of scientific endeavour in support of the development of centralised storage and marketing agencies in the developing countries, the success of P. truncatus at farm level in Africa could be a salutary reminder that we are in no position to assume that we will be able to set aside the pest problems of the subsistence farmer, on whom so much depends, in the years to come.

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