An analysis of the importance of liposcelids in tropical large-scale storage

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Abstract

Recent advances in knowledge concerning liposcelid infestations have raised questions as to the importance of these pests. Laboratory studies have shown that liposcelids can cause a small dry-weight loss to stored milled rice. Studies in Indonesia suggested that very heavy infestations could be associated with the use of phosphine and residual insecticides. Laboratory trials have shown liposcelid eggs to be tolerant to the phosphine concentrations frequently attained in sheeted-stack fumigations, and field trials have confirmed the limited efficacy of residual insecticides. The significance and economic importance of these results are discussed.

Introduction

The literature shows that the majority of psocid species that infest stored products in the tropics belong to the genus *Liposcelis* (Kleih and Pike 1994). A survey in Indonesia revealed *L. entomophila* to be the most abundant species followed by *L. bostrychophila*; *L. paetus* was also present (Haines and Pranata 1982). Liposcelids were found to be common and often very abundant in cereal stores, in particular in hot, humid areas (Haines and Pranata 1982).

A review of the literature showed that little research has been focused on the significance of these insects within the storage environment. In recent years, research on liposcelids at the Natural Resources Institute (NRI) has attempted to address the important issues and answer some of the questions arising from them. Studies have been undertaken to: establish information on their basic biology; quantify losses caused; assess the efficacy of control techniques against them; and evaluate their economic importance.

Biology of Liposcelids

A recent survey of Indonesian and Indian large-scale milled rice bag stores reported that the incidence and extent of infestations are frequently greater during rainy seasons (Kleih and Pike 1994); this confirmed similar observations made by Haines and Pranata (1982). Laboratory research demonstrated that *L. entomophila*, *L. bostrychophila* and *L. paetus* bred most rapidly at 70–80% r.h. (Rees and Walker 1990). Comparable humidity levels prevail within stores during the rains. This indicates that the Rees and Walker study can be used to predict conditions under which liposcelids are less likely to proliferate. Reducing the r.h. to below 60% at temperatures of 30°C or less can be expected to limit liposcelid numbers. Store managers responsible for bulk storage facilities may be able to limit infestations using suitable aeration techniques.

Assessment of Milled Rice Weight Loss Due to Liposcelid Infestation and the Impact of Degree and Method of Milling

Laboratory trials have been undertaken to assess the levels of milled rice weight loss caused by liposcelid infestations of *L. paetus*. The results of the study suggest that this species can survive and breed on milled rice alone and is capable of causing a small dry-weight loss. The extent of the loss depended upon the degree of milling and the insect numbers.

Over a 14-week study period, lightly-milled rice supported a significantly greater rate of population increase than well-milled rice and as a consequence suffered greater weight loss. Biochemical analysis showed that post-infestation levels of lipid, and to a lesser extent protein, decreased on lightly-milled rice but not on well-milled samples. This suggests that the protein and lipid content of the bran layer promotes more rapid liposcelid population growth, but the insects are capable of surviving and breeding on endosperm alone.

Although it is unwise to extrapolate directly to other insect species, it was considered that *L. paetus* probably acts as an adequate model for *L. entomophila*, the more frequent pest in Southeast Asia. This pest has proven very difficult to maintain and work with under laboratory conditions.

If a 'typical' liposcelid infestation is represented by a stable population of 4000 insect/kg, then over a four-month storage period (based on field data) the anticipated level of dry-weight loss equates to 0.2%.

A separate study investigated the effect of two different milling methods. The results showed that abrasively-milled rice promoted greater *L. bostrychophila* productivity than friction-milled rice (Mr P. Clarke, unpublished data). Why this proved to be the case has yet to be established, but the information does provide a further insight into how liposcelid numbers could potentially be reduced.

Laboratory-based Assessment of Phosphine and Methyl Bromide Efficacy

Phosphine and methyl bromide are used worldwide as fumigants for controlling insect pests of stored products.

Field observations in Indonesia suggested that heavy infestations of *Liposcelis* in large-scale storage facilities were associated with the use of the fumigant phosphine (Haines and Pranata 1982).

Phosphine plays a major role in the pest control strategy of BULOG in Indonesia. Stocks are treated at three-monthly intervals with 2 g of PH_3/t of rice with an exposure period of four days (Sidik et al. 1985). In India, a seven-day exposure period is advocated at a similar application rate. Store

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managers noted that heavy and rapid re-infestation often occurs after these treatments.

Methyl bromide is used to a lesser extent in Indonesia. The level of use is unlikely to increase as it has been classified as an ozone-depleting gas. Methyl bromide is not used in India.

Laboratory trials have been undertaken to investigate the tolerance of all life stages of *L. entomophila* to both phosphine and methyl bromide.

Phosphine

The results from populations of adults and nymphs showed that a phosphine concentration of 0.05 mg/L, for an exposure period of 24 hours was sufficient to achieve 100% mortality. Investigations by Kalinovic (1984) with *L. bostrychophila* provided comparable results. In contrast, *L. entomophila* eggs exhibited a high degree of tolerance to the fumigant. A concentration of 1.7 mg/L for five days was required to kill 99% of the eggs. To achieve 100% mortality the fumigation period needs to be extended to eight days to ensure that all the nymphs have hatched and the insects are killed at the more susceptible nymphal stage (assuming a minimum gas concentration of 0.05 mg/L remains).

A further option is to carry out two fumigations ten days apart as recommended for the control of mite infestations (Dr C. H. Bell, unpublished report). Careful consideration would have to be given to the cost-benefits of the different control strategies prior to implementation.

Liposcelid eggs have a relatively long development period compared to other stored-product pests (Shires 1982; Pike 1990). The eggs of *L. entomophila* used in this study had a mean development period of 6.4 days at 30°C and 70% r.h. Their apparent slow metabolic rate may contribute to their tolerance to phosphine.

The survival of a large proportion of eggs could explain the situation observed in milled rice stores where heavy infestations of *Liposcelis* spp. can occur only a few weeks after an apparently successful phosphine fumigation. Store managers often attributed this phenomenon to cross-infestation (Kleih and Pike 1994). It now seems more likely that the adults and nymphs are killed by the fumigation practices employed, but the concentrations are too low and the exposure periods too short to kill the eggs. The rapid increase in infestation density may also be attributable, to the suppression of cheyletid mites, natural predators, which may be more susceptible to control strategies than their prey.

Methyl bromide

All the life stages of *L. entomophila* proved to be susceptible to methyl bromide at moderately low CT products. Again the eggs proved to be the most tolerant life stage. Probit analysis of the egg data gave an LD 99 of 43.5 mg/L/hour.

The results of the methyl bromide fumigation trials indicate that *L. entomophila* is readily controlled if good fumigation practices are observed. However, field validation tests should be conducted in order to confirm this statement.

Evaluation of the Efficacy of Residual Insecticides

It is common practice in the tropics to respray store and stack surfaces at regular intervals after fumigation in an attempt to limit reinfestation of insect-free stacks and to prolong the period until refumigation is required. A field study in Indonesia investigated the validity and the cost efficiency of this claim. A study of liposcelid numbers was included in this trial (no attempt was made to differentiate between species). Fumigated milled rice bag stacks were sprayed at four-weekly intervals with fenitrothion e.c. (emulsifiable concentrate) or w.p. (wettable powder). Liposcelid population levels in the e.c. treated stacks were very similar to those recorded in the controls. The stacks treated with w.p. actually showed elevated liposcelid numbers (Hodges et al. 1992). The key finding was that treating the stacks with insecticide offered no protection against liposcelids.

Laboratory-based studies have suggested that liposcelids may not be susceptible to pyrethroid residual insecticides (Pranata et al. 1983; Pinniger 1984; Turner et al. 1991). Far higher mortality rates were recorded for organophosphates such as fenitrothion. The laboratory results of contact trials for *L. bostrychophila* against an absorbent surface (plywood squares) treated with fenitrothion w.p. suggests that good control can be achieved assuming a 30-minute contact time and a minimum active ingredient concentration of 0.07 g/m^2 (Turner et al. 1991). In the field trials (Hodges et al. 1992) the active ingredient application rate used was 1.0 g/m^2. This suggests that the insects remain in contact with the treated surface for an insufficient amount of time or the surfaces were very absorbent or the active ingredients quickly break down.

The six-month field trial conducted by Pranata et al. (1983) tested the efficacy of admixing permethrin dust with rice. The authors concluded that up to concentrations of 5 ppm of permethrin Liposcelid populations were unaffected by the insecticide and benefited from the reduction in competitors and enemies.

These results strongly suggest that such treatment protocols are of no benefit and should not be advocated. The resources being expended on residual insecticides would be put to more effective use if they were to be diverted to improving fumigation practices.

Economic Assessment of the Importance of Liposcelids

The survey of Indonesian and Indian large-scale rice stores showed that the store managers generally regarded liposcelids as nuisance pests. Many thought that the insects consumed moulds, dust and in some cases the jute bag, rather than the rice, and were of little economic importance (Kleih and Pike 1994).

Increases in costs due to liposcelid infestations were assessed, taking into account increased labour and material costs (Kleih and Pike 1994) combined with the weight loss quantified in laboratory studies. The total costs incurred per annum, assuming the rice is infested for four months at a typical infestation level, amounted to £47 000 in Indonesia and £114 000 in India.

The nuisance value of the liposcelid infestations possesses its own intangible costs. Uncontrolled heavy infestations causes ill will between store managers and the workers. The insects cause itching and may be inhaled, potentially leading to respiratory problems. These factors could lead to reduced productivity of store staff.

Many countries that import infestable commodities require a certificate confirming freedom from insect infestation. Expansion of export markets could be lost if infestations go unchecked.

Conclusions

Contrary to the expectations of many store managers, liposcelids can be the cause of weight loss in stored rice. Although such losses are likely to be relatively low, the development of extensive liposcelid populations is a significant disadvantage for marketing agencies increasingly subjected to stricter quality and hygiene requirements.

On the basis of prospective economic benefits it is difficult to justify the development of separate control strategies for liposcelids. A viable approach would be to adapt effective existing control practices that work well for pests of greater economic significance. These practices could include the introduction of improved phosphine fumigation or the use of sealed storage where stocks are to be maintained in the long term. Alternatively, adoption of higher quality standards and alteration of the physical conditions could serve to limit liposcelid population increase. The control of these pests will become more difficult if the planned moves to ban or limit the use of methyl bromide come into effect.

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