Susceptibility of grain legume species to redlegged earth mite (*Halotydeus destructor* Tucker) damage at the seedling stage

D.J. Thackray[AB], T.J. Ridsdill-Smith[AC] and D.J. Gillespie[AB]
[A] Co-operative Research Centre for Legumes in Mediterranean Agriculture, University of Western Australia, Nedlands, Western Australia 6907, Australia.
[B] Agriculture Western Australia, Locked Bag No. 4, Bentley Delivery Centre, Western Australia 6983, Australia.
[C] CSIRO Division of Entomology, Private Bag, PO Wembley, Western Australia 6014, Australia.

Summary
Six species of grain legumes were assessed for seedling resistance to the redlegged earth mite, *Halotydeus destructor*. The numbers of mites on plants, damage to leaves and effects on plant dry matter were assessed in choice and no-choice experiments. Field peas and faba beans suffered severe damage from the feeding of large numbers of mites. Fewer mites fed on lentils which suffered less damage. Mites caused severe damage to the cotyledons but considerably less damage to the true leaves of narrow-leafed lupins. Although mites were present on the leaves of albus lupins the plants suffered no damage and there was no effect of mites on their shoot or root dry weights. No mites were found on chickpeas and no damage was seen. When mites were given a choice of species to feed on, the relative damage to each species was similar to that found when mites had no choice. The exception was lentils which were relatively less damaged than in the no-choice experiment.

Introduction
Grain legume production in Australia has increased more than 50-fold in the last 25 years, with the potential for 0.5 million hectares of pulses (grain legumes for human consumption), such as faba beans (*Vicia faba* L.), lentils (*Lens culinaris* Med.), albus lupins (*L. albus* L.), and chickpeas (*Cicer arietinum* L.) etc., in Western Australia alone by the year 2000 and possibly one million hectares within a decade (Siddique *et al.* 1995a, Siddique *et al.* 1995b). A range of new grain legume species and lines is being investigated in Western Australia for widespread adoption (Siddique *et al.* 1993). Most originate in countries where redlegged earth mite, *Halotydeus destructor* (Tucker), is not found and therefore its potential for damage is not known. Selecting new or improved grain legumes, adapted for profitable use in farming systems in Mediterranean-type regions of Australia, is a primary focus for the Co-operative Research Centre for Legumes in Mediterranean Agriculture (CLIMA), based in Western Australia. The main criteria used in selecting promising species and lines are adaptation to climate, soil type and soil pH, along with improved yields, nutrition, quality and disease resistance. However, new species are likely to be susceptible to a range of pests including *H. destructor*.

Halotydeus destructor is widespread throughout the winter rainfall areas of southern Australia affecting almost all agricultural land (Wallace and Mahon 1971). It can cause severe damage in crop and pasture legumes (Gillespie and Nicholas 1989). Estimated losses through pasture damage (including costs of control) are $145–201 million annually to the livestock industry alone (Ridsdill-Smith 1991). Other crops such as canola (*Brassica napus* L.) can also be severely attacked by it (McDonald *et al.* 1995) and many plant species are particularly vulnerable at the early seedling stage. The development of new grain legume cultivars resistant to *H. destructor* could provide an effective way to reduce both crop damage and dependence on the use of pesticides for control.

At present only anecdotal evidence is available on relative susceptibilities to *H. destructor* of grain legumes, such as field peas (*Pisum sativum* L.), faba beans, narbon beans (*Vicia narbonensis* L.) and lentils. In the autumn of 1994 there were severe attacks on some grain legumes, particularly in emerging crops and trial plots planted in rotations following pasture (Siddique personal communication). In some cases, crops were killed by *H. destructor* attack soon after emergence and many others were severely stunted. Growers are concerned that there is no reliable information to indicate which species or cultivars are most susceptible to attack. They also require information on whether badly damaged plants can recover sufficiently to give expected yields, especially when they are growing under stress conditions, such as drought or cold. Growers are faced with difficult decisions on whether or not to spray against *H. destructor* in autumn and if so, which crop species or cultivars should have priority.

The aims of this controlled environment investigation were to assess relative susceptibilities to *H. destructor* of seedlings of six grain legume species and to quantify the effects of damage on early plant growth and vigour.

Materials and methods

No-choice experiment
Plant material. Commercial cultivars of chickpea, albus lupin, narrow-leafed lupin (*Lupinus angustifolius* L.), lentil, faba bean and field pea were studied. White plastic tote boxes (44 × 32 × 21 cm) with drainage holes were filled to 7 cm deep with a 7:4 river sand:peat mix with added nutrients. Seed was sown 1 cm deep in rows into the boxes. A pilot study (unpublished), in which average field densities of mites (approximately 20 000 m^{-2}) were introduced to faba bean seedlings, identified that with 100% emergence, sowing 10 seeds (6 g) in a tote box gave rise to plant densities appropriate for securing susceptibility ratings with neither too little nor too much seedling damage. Therefore in the no-choice experiment the same total seed weights per tote box (6 g assuming 100% emergence) were used for each legume species to offer similar quantities of seedling plant material to mites. This resulted in different numbers of plants on offer, depending on the seed size of each cultivar (Table 1). Since *H. destructor* is very mobile it was assumed that the differences in seedling numbers between species would not alter the likelihood of attack or amount of overall damage.

Table 1. Plant species, cultivar, quantity of seed sown and number of plants used in the no-choice experiment.

Plant species	Cultivar[A]	Weight per seed (g)	No. seeds sown	No. plants retained / box
Chickpea (Desi)	Tyson	0.15	80	40
Albus lupin	Kiev mutant	0.5	24	12
Narrow-leafed lupin	Gungurru	0.15	80	40
Lentil	Digger	0.05	240	120
Faba bean	Fiord	0.6	20	10
Field pea	Dundale	0.25	48	24

[A] Recommended by K.H.M. Siddique, Agriculture Western Australia, as representative of commercial plantings in the field in 1994.

Two replicate boxes of each species were planted, the number of replicates being restricted by space available. The number of seeds planted was double the number of plants required (i.e. 12 g per box) to allow for differences in percentage germination. The appropriate *Rhizobium* peat inoculum for each species was mixed with water to a slurry and poured over the seed, before filling in the rows with more soil. To compare damaged and control plants, tote boxes were divided equally in two with perspex sheets so that mites could be introduced to one side only. Boxes were arranged in a randomized block design in plastic watering trays on benches in a controlled environment room, with a 17/11°C, 10/14 hour day/night cycle. The humidity in the rooms changed between 48–56% under lights and 92–98% in the dark. Five days after sowing, seedlings in excess of the number required (i.e. number approximating to 6 g seed) were removed, leaving an even distribution either side of the perspex dividers. The top edges of boxes were smeared with vaseline to prevent escape of introduced mites.

Mites. *Halotydeus destructor* were collected from a mixed subclover pasture at Chestervale Farm, Toodyay, Western Australia (31°33'S, 116°4'E), using a mechanical vacuum collection device (Wallace 1972). They were placed in containers for transport back to Perth where they were used within 24 hours.

Screening for susceptibility and growth effects. The screening techniques used in these experiments were modified from those of Gillespie (1993). Mites were weighed before applying to experiments and sub samples taken to provide estimates of numbers applied and proportions of each growth stage. 0.125 g of *H. destructor* was added to one side of each box of narrow-leafed lupins, albus lupins, and lentils one week after sowing, two days after plant emergence. The other side of each box acted as a control, with no mites applied. Mites were added a day later to the peas and chickpeas and two days later to the faba beans which were slower to emerge. In order to maintain densities (following apparent mortalities) another 0.125 g of *H. destructor* was added to each box a week after first introduction, resulting in a total of 0.25 g of mites being applied to each replicate. With an even distribution of all growth stages, 0.25 g represents approximately 2500 mites, equating to a total application of 35 000 mites m^{-2} before mortalities or 17 500 mites m^{-2} at each application to one half of a box.

The numbers of mites on plants were counted 11 days after mites were first added. The percentage damage was scored individually for cotyledons of species in which these were produced above ground and for true leaves. Leaf silvering indicated areas of damage and the percentage of the leaf surface affected was estimated by eye. An overall score for total plant damage was also made. Plant heights were measured and any abnormal growth effects noted. After 14 days mites were removed and the plants washed, separated into roots and shoots and weighed. Weighed material was placed in drying ovens at 40°C and dry weights obtained seven days later.

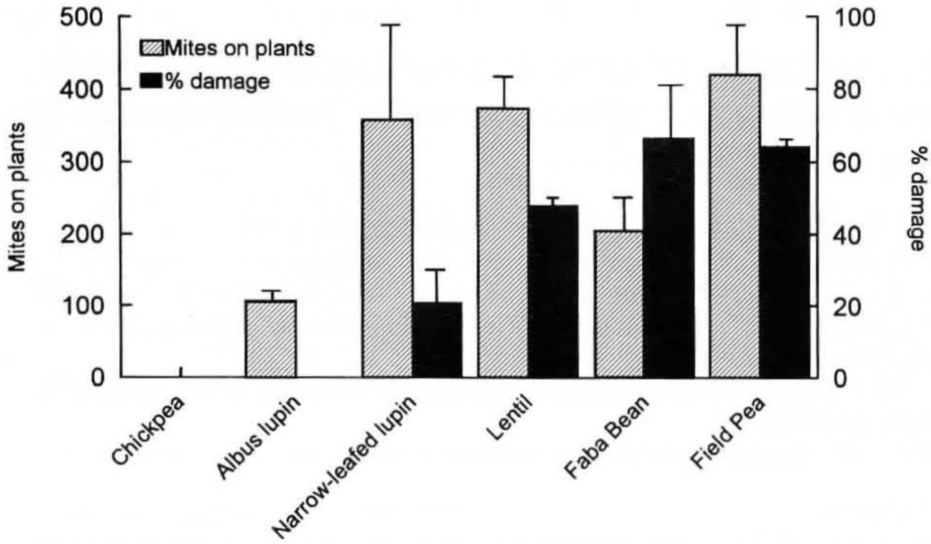

Figure 1. Numbers of mites on plants (n=2) and per cent total plant damage for six grain legume species in the no-choice experiment. Differences in mite numbers and damage were not quite significant. Vertical bars denote standard errors.

Choice experiment

Plant material. In this experiment all six legume species used in the no-choice study were on offer to *H. destructor* within the same tote box. The same boxes, soil, planting and inoculation techniques and growing conditions were used as for the no-choice experiment, but no perspex dividers were included. A total of 12 g of seed was planted in each tote box, with numbers of seed of each species calculated to contribute one sixth (i.e. 2 g) of the total seed weight planted. Individual seed was sown to give an even distribution of each species throughout each box. Four replicate boxes were sown and placed in the controlled environment room. After emergence seedlings were removed to leave numbers of each species equivalent to approximately 1 g of seed material per box. Seedling numbers per box were field pea 4, faba bean 2, lentil 20, narrow-leafed lupin 7, albus lupin 2, chickpea 7. Since *H. destructor* is very mobile, adults being capable of traversing the length of a box within 30 seconds, the number of plants of each species available was not believed to influence mite selection. The numbers planted ensured equal amounts of leaf material were on offer from each species.

Screening for susceptibility and growth effects. One week after planting, when all species had emerged, 0.25 g of field collected mites were added to each tote box. In faba beans, which emerged slowest, the cotyledons were still partly closed. The numbers of mites on individual plants and the percentage damage were assessed 11 days after mites were first added. Dry weights were not taken, since the effects of damage on growth rate were similar for each species compared with the no-choice experiment.

All data were tested by analysis of variance using the statistical package Genstat 5. Fishers' protected least significant difference test was used to establish where differences between species lay.

Results

Halotydeus destructor damage is characterized by 'silvering' of the leaves, caused by the removal by mites of plant sap from cells beneath the epidermis (Jeppson *et al.* 1975). Some batches of field collected mites were slightly contaminated with lucerne flea (*Sminthurus viridis* L.). These proved impossible to remove, but flea damage was characteristic ('shot holes' through leaves) and could therefore be excluded from the *H. destructor* damage scores. As *S. viridis* damage was minimal it was not thought to contribute to growth effects.

No-choice experiment

After 11 days infestation mites had caused severe effects on both upper and lower leaf surfaces and cotyledons of faba beans and field peas, damaging over 60% of the total leaf area (Figure 1). Although the amount of damage was similar for the two species, fewer mites were seen on faba beans than on field peas. Lentils were also damaged considerably (48% of total leaf area) with similar numbers of mites on plants as for field peas. The cotyledons of narrow-leafed lupins were severely damaged (up to 100% silvering of leaf surfaces) but very little damage was seen on the true leaves, although mites were seen feeding on their undersurface. Some mites were observed on albus lupins but no damage was seen. No mites were seen feeding on chickpeas, even though no other food was available, and few mites were seen in boxes after 11 days. There was no damage visible in chickpeas.

Halotydeus destructor reduced dry matter of field peas and faba beans by around 40% (Figure 2). Lentil dry matter was reduced by nearly 25%. Narrow-leafed lupins were less affected despite considerable cotyledon damage, with overall reductions in dry weights of 15%. The patterns were similar for shoots and roots in most species, although in narrow-leafed lupins the reduction in dry matter was greater in the roots. There were no reductions in dry matter weights for albus lupins and chickpeas.

Choice experiment

After 11 days mites had colonized field peas, narrow-leafed lupins and faba beans significantly more heavily than lentils or albus lupins, while none was found on chickpeas (Figure 3). Excepting lentils, which hosted significantly fewer mites, the trend was similar to that in the no-choice experiments. Damage was again greatest to field peas and faba beans (50–70%), with less to narrow-leafed lupins (15–25%) and no visible damage to albus lupins or chickpeas. Lentils were again the exception, with significantly less damage (25%) than in the no-choice experiment (48%).

Discussion

A range of mite damage was seen between the six grain legume species tested, from severe damage to none. Field peas with severe visual damage at the seedling growth stage were heavily colonized by mites. Faba beans were also severely damaged by mites, although less mites were seen on beans than on peas and narrow-leafed lupins, when observed 11 days after introduction. The lower mite numbers on beans may have been due partly to the large amount of damage already inflicted by this date, leaving little plant material for feeding. Mite numbers on faba beans were high earlier in the experiment but were not recorded. Damage to peas and beans was reflected in the poor growth rates and low dry weights, compared with controls, for both shoot and root material from infested plants. Lentils suffered comparatively less damage, particularly when mites had a choice of food species, but dry matter was reduced by infestation in the no-choice situation. Mite numbers on narrow-leafed lupins were high, especially in the choice experiment. However, although cotyledon damage was severe in narrow-leafed lupins, feeding on true leaves appeared light and subsequent effects on plant growth were minimal. This illustrates the need to understand the longer term effects of mite damage on crop growth and yields, under a range of field conditions. Gungurru narrow-leafed lupins may show some tolerance or resistance to mites.

Chickpeas and albus lupins were resistant or tolerant to *H. destructor*. The mites probably avoid chickpeas due to the acidic liquids produced by trichomes on the leaves and shoots of these plants (Lazzaro and Thomson 1995). Other insects have been shown to be adversely affected by the malic acid secretions from chickpeas and Bosque-Perez and Buddenhagen (1990) reported high mortality (70–100%) amongst aphids on chickpeas with glandular hairs, in contrast to low mortality on a hairless mutant.

In the choice experiment the number of mites on plants of all species except chickpeas was lower than in the no-choice

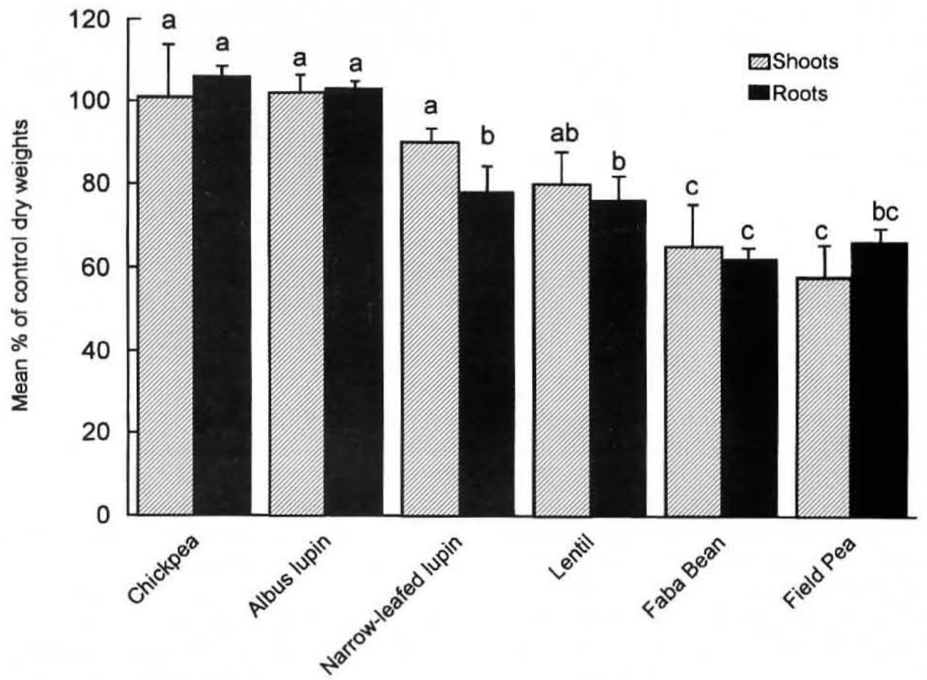

Figure 2. Shoot (total material above ground) and root dry weights as a mean percentage of undamaged control plants for six grain legume species in the no-choice experiment. Columns headed with the same letters are not significantly different for shoots ($F_{5,6}$ = 9.5, P<0.01, LSD = 17.1) and roots ($F_{5,6}$ = 18.9, P<0.001, LSD = 12.0). Vertical bars denote standard errors.

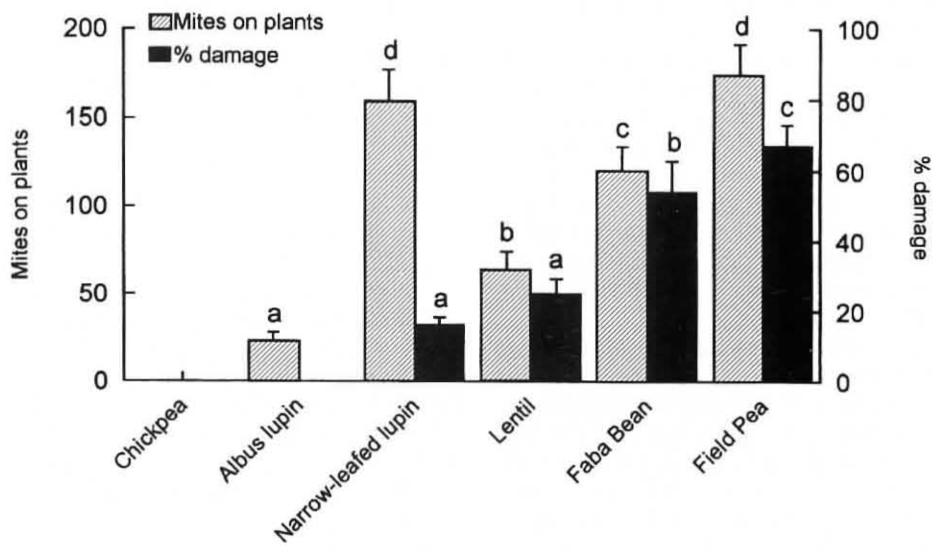

Figure 3. Numbers of mites on plants (n=2) and per cent total plant damage for six grain legume species in the choice experiment. Columns headed with the same letters are not significantly different for mites ($F_{4,12}$ = 22.75, P<0.001, LSD = 37.9) and damage ($F_{3,9}$ = 30.99, P<0.001, LSD = 12.2). Vertical bars denote standard errors.

experiment. The percentage damage seen was similar to that in the no-choice experiment for peas, beans and lupins. However, lentils were the exception with less damage compared with other species than there had been in the no-choice experiment. This may have implications in the field. For example, where plants of another crop species are present as volunteers within the same paddock or as crops in adjoining fields, which are 'preferred' by mites, less damage may occur to the lentil crop. When investigating feeding and population growth of *H. destructor* on different crop and pasture species under controlled environmental conditions, McDonald *et al.* (1994) found that when mites were offered a choice, significantly more time was spent feeding on vetch, canola and capeweed than on lupins, wheat or medic.

The effects of *H. destructor* damage on long term survival, growth rates, final yield and quality in grain legumes have not been assessed, although partial crop failures have been seen in commercial situations. In assessing the resistance of four white clover cultivars to attack by *H. destructor* under controlled environmental conditions, Stahle (1987) recorded up to 68% mortality in damaged seedlings, with growth rates of surviving plants significantly affected. Under field conditions the effect of seedling damage on plants may be enhanced by climatic stresses such as cold or drought. Further study is required to investigate the effects of seedling damage on later plant growth, and to assess the economic advantage of protecting newly established crops of grain legume species such as peas, faba beans and lentils against mites.

This preliminary work has shown that there are considerable differences in susceptibility to *H. destructor* between the six selected species of grain legumes. The major findings from this study under controlled environmental conditions are consistent with field observations (K.H.M. Siddique personal communication), where in both commercial crops and field trials in 1994 severe damage was found in faba beans and field peas, whilst lentils also suffered considerable damage in some situations. Some damage was observed in narrow-leafed lupins, with no apparent long-term effects. A little damage was found in albus lupins, but no damage occurred in crops or plots of chickpeas.

The species differences shown are based on experiments with only two (no-choice) or four (choice) replicates. However, with a screening method now developed for use under controlled environment conditions, more rigorous study should indicate which species and cultivars are most at risk to mite damage and determine the effects of damage on final yield and quality. With field screening to confirm results, growers will be better equipped to make decisions on the suitability of different grain legumes to their location, their place in the crop rotation and the importance of a carefully timed pesticide application against mite damage. Based on the current findings, farmers are advised that they should be particularly diligent in assessing mite activity in field pea and faba bean crops at and before crop emergence, and be ready to consider applying a spray to control damage at this highly susceptible growth stage. In the longer term, screening of new lines of both established and potential new grain legume species will assist in the development of cultivars with useful resistance to *H. destructor* and hence reduce the need for chemical and other means of control in areas known to be affected by this pest.

Acknowledgments

The authors thank Dr. K.H.M. Siddique (Agriculture Western Australia and CLIMA) for guidance, provision of seed material and critical comments on the manuscript. Agriculture Western Australia provided research facilities, CLIMA and IWS funded the controlled environment rooms and D.J. Thackray was funded by CLIMA.

References

Bosque-Perez, N.A. and Buddenhagen, I.W. (1990). Studies on the epidemiology of virus disease in chickpea in California. *Plant Disease* 74, 372-8.

Gillespie, D.J. (1993). Redlegged earth mite (*Halotydeus destructor*) resistance in annual pasture legumes. *In* 'Pests of pastures: weed, invertebrate and disease pests of Australian sheep pastures', ed. E.S. Delfosse, pp. 211-13. (CSIRO, Melbourne.)

Gillespie, D.J. and Nicholas, D.A. (1989). The effect of redlegged earth mite (*Halotydeus destructor*) on legume productivity. Proceedings of the XIV International Grasslands Congress, Nice, France, pp. 215-6.

Jeppson, L.R., Kiefer, H.H. and Baker, E.W. (1975). 'Mites injurious to economic plants'. (University of California Press, Los Angeles).

Lazzaro, M.D. and Thomson, W.W. (1995). Seasonal variation in hydrochloric acid, malic acid and calcium ions secreted by the trichomes of chickpea (*Cicer arietinum*). *Physiologia Plantarum* 94, 291-7.

McDonald, G., Moritz, K., Merton, E. and Hoffman, A.A. (1995). The biology and behaviour of redlegged earth mite and blue oat mite on crop plants. *Plant Protection Quarterly* 10, 52-5.

Ridsdill-Smith, T.J. (1991). A contribution to assessing the economic impact of redlegged earth mite on agricultural production in Australia. *Plant Protection Quarterly* 6, 168-9.

Siddique, K., Loss, S. and Pritchard, I. (1995a). Pulses – profitable new crops for the wheatbelt. *Western Australian Journal of Agriculture* 36, 112-5.

Siddique, K.H.M., Loss, S.P. and Thomson, B.D. (1995b). Growth, yield and adaptation of grain legumes in Mediterranean type environments of Western Australia. *Food Legume Newsletter, ACIAR* 22, 5-9.

Siddique, K.H.M., Walton, G.H. and Seymour, M. (1993). A comparison of seed yields of winter grain legumes in Western Australia. *Australian Journal of Experimental Agriculture* 33, 915-22.

Stahle, P.P. (1987). Resistance of four white clover cultivars to attack by redlegged earth mite. *In* 'Temperate pastures: their production, use and management', eds. J.L. Wheeler, C.J. Pearson, and G.E. Robards, pp. 232-4. (CSIRO, Melbourne).

Wallace, M.M.H. (1972). A portable power-operated apparatus for the field-collecting of epigaeic collembola and acari. *Journal of the Australian Entomological Society* 11, 261-3.

Wallace, M.M.H. and Mahon, J.A. (1971). The distribution of *Halotydeus destructor* and *Penthaleus major* in Australia in relation to climate and land use. *Australian Journal of Zoology* 19, 65-76.