Systematic studies of redlegged earth mite *Halotydeus destructor* (Tucker) and related species (Acarina: Penthaleidae)

T.K. Qin and **R.B. Halliday**, CSIRO Division of Entomology, GPO Box 1700, Canberra, ACT 2601, Australia.

Summary

Five species of *Halotydeus* and three species of *Penthaleus* occur in Australia, but only *H. destructor* (redlegged earth mite) and *P. major* (blue oat mite) are pests of pasture. Apart from a new species of *Penthaleus* which is also present in pasture and whose importance is yet to be determined, all the other species occur in native habitats and have no economic importance. Morphological and electrophoretic studies have shown that *H. destructor* is not subdivided into varieties or biotypes. *H. destructor* is probably native to South Africa or South America and both areas should be considered in the search for its natural enemies.

Introduction

Halliday (1991) reviewed the early literature on redlegged earth mite *(Halotydeus destructor* Tucker), and found that there has been no comprehensive taxonomic work that allows the species to be recognised with complete confidence, and that some past records of it could refer to other species, such as the blue oat mite *Penthaleus major* (Dugès). He also pointed out that its native range has not been established with any certainty. The present paper reports the results of a project whose objectives were:

i. to determine how many species of *Halotydeus* and *Penthaleus* occur in Australia,
ii. to develop means of distinguishing between these species and
iii. to determine whether South African and Australian populations of *H. destructor* are subdivided into varieties or biotypes.

It also presents new information on the distribution of *H. destructor* and hypotheses on its place of origin.

The number of species of *Halotydeus* and *Penthaleus* in Australia

The genera *Halotydeus* and *Penthaleus* were last studied taxonomically in Australia by Womersley (1941), who included two species of each genus. We have re-examined the specimens used by Womersley and Wallace in previous taxonomic studies of the group, and collected further specimens throughout southern Australia. On the basis of these specimens, we now recognise five species of *Halotydeus* from Australia—*Halotydeus destructor* (redlegged earth mite), *Halotydeus* new species number 1 (originally identified as *H. egregius* by Womersley 1941), *Halotydeus* n. sp. 2 (from the Armidale area), *Halotydeus* n. sp. 3 (from the Newcastle area), *Halotydeus* n. sp. 4 (from Norseman in Western Australia, Coulta in South Australia, and possibly Cairns in Queensland). Three species of *Penthaleus* occur in Australia—*Penthaleus major* (blue oat mite), *Penthaleus minor* (Canestrini), and *Penthaleus* n. sp. 1 (from New South Wales, South Australia and probably Victoria). All the new species will be formally named and described elsewhere. They can be distinguished morphologically by the position of the anus, the structure of the chelicerae, and by details of the number and arrangement of setae on the body and legs.

Pest status of the species

Penthaleus minor and the new species of *Halotydeus* are all from native habitats (forest, moss, saltbush) and apparently have no economic importance. *H. destructor* and *P. major* are pests of pasture. *P.* n. sp. 1 occurs (apparently together with *P. major*) in leguminous pasture but its range has not been defined and its importance has not been assessed.

Distribution of *H. destructor*

The old literature on *H. destructor* contains incorrect and unreliable records of its geographic distribution. Halliday (1991) corrected these mistakes. Currently, *H. destructor* is known reliably only from South Africa, Australia and New Zealand. Recent collecting has shown that its distribution in both South Africa and Australia is wider than previously reported.

Australia and New Zealand

H. destructor is distributed across the southern part of mainland Australia, and occurs in Tasmania. Wallace and Mahon (1971) provided detailed distribution maps of *H. destructor* in Australia. They stated that its distribution in Western Australia could be given with some precision because intensive collecting had been done there. No mites were found at Southern Cross, Coolgardie, or Norseman. However, during a collecting trip in 1993, specimens of *H. destructor* were obtained from all these areas. In New South Wales, *H. destructor* has been found in large numbers in Hay, Wentworth and Molong where it was not reported by Wallace and Mahon (1971). These new records represent significant extensions of the species' range inland. In New Zealand, *H. destructor* is only found in a limited area (Wallace and Mahon 1971).

South Africa

The distribution of *H. destructor* in South Africa has not been documented in detail, but it was believed that its eastern limit was George and its north-western limit was Namaqualand. A recent collecting trip has allowed us to define this distribution in more detail. We now know that the species occurs in a crescent-shaped area from Steinkopf in Namaqualand, east as far as Humansdorp, near Port Elizabeth. It can generally be found in areas from the coast to 100–150 (at most 200) km inland.

Food plants of *H. destructor*

Redlegged earth mite is polyphagous. Jack (1908) listed many vegetable crops being attacked by *H. destructor* in Cape Town. Tucker (1925) stated that, with the exception of trees, shrubs, onions, and possibly a few varieties of flowers, not a single weed, vegetable, or cultivated flower was found to escape its attack. The mite feeds on native as well as introduced annual plants. It has been reported on cape weed (*Arctotheca calendula*), cereals, flowers, vegetables, potatoes, radish, lucerne, clover, sweet lupins and tobacco (Jack 1908, Tucker 1925, Newman 1931, Meyer 1981). *H. destructor* has also been found on oat grass and other grasses, flat weed, Patterson's curse, *Gazania* sp., *Osteospermum* spp., *Oxalis* spp., *Senecio* sp. and *Tephrosia* spp. in South Africa (personal observations).

Biosystematics of *H. destructor*

Morphological study

We examined 24 populations of *H. destructor* from across the species' entire distributional range in Australia. Ten specimens from each population were mounted on microscope slides and examined morphologically. We also measured them, on the basis of smaller numbers of specimens. We examined more than 80 morphological characters in each specimen, including measurements of the body, measurement of the length of 28 different leg segments, measurements of various structures that make up the mouthparts, the number and arrangement of setae associated with the mouthparts, the number and arrangement of setae on the legs and body, the length of setae on the legs and body, the size and shape of the genitalia, the number and arrangement of setae associated with the genitalia, and all the characters that were used to separate the different species. These morphological characters did not show any differences between any of the populations. There is occasionally an extra seta on the dorsal surface of tarsus I, but this varies within populations, and appears to have no special significance. More studies, especially on South African specimens, are in progress.

Genetic study

Specimens from 47 Australian populations have been screened using cellulose acetate gel electrophoresis. To date, 17 presumptive enzyme loci have been identified, and seven of these show genetic variation (*Esterase*, *Glucose Phosphate Isomerase*, *Glucose-6-Phosphate Dehydrogenase*, *Isocitrate Dehydrogenase*, *Malate Dehydrogenase-2*, *Phosphoglucomutase*, *6-Phosphogluconate Dehydrogenase*). The most common allele at each locus is the same in all populations examined. Populations vary in the frequency of some alleles, but there are no fixed genetic differences among populations. This is the pattern that would be expected in a single species that was not subdivided into races or strains. Work is proceeding with additional populations from South Africa.

Hypotheses on the place of origin of *H. destructor*

South Africa-Namaqualand origin

Namaqualand is situated in the north-western corner of South Africa. It has a very low, sporadic winter rainfall which has given rise to adaptations of plants for survival during moist winters and dry, hot summers. Annual plants, which *H. destructor* principally feeds on, avoid the dry period by quickly germinating, growing, flowering and setting seed during the moist winter and spring, then dying off and surviving the dry summer and autumn in the form of seed. *H. destructor* has a similar life cycle and is also present in Namaqualand. It is possible that *H. destructor* has evolved with these plants. The eggs of the mites hatch after winter rains and the mites reproduce during winter and spring, then produce aestivating eggs to survive the hot summer. It is possible that *H. destructor* was introduced from Namaqualand to Cape Town, and then spread to other parts of the country.

After some weeks in Cape Town looking for possible natural enemies of *H. destructor*, Womersley (1933) challenged the idea that it was native to South Africa, and suggested that it may have been introduced from the Mediterranean climate area of southern Europe. However, M. M. H. Wallace made intensive collecting in this area but did not find *H. destructor* (Halliday 1991). A further possibility for the origin of *H. destructor* is South America.

South America-Chile origin

Wallace and Mahon (1971) indicated that climatic conditions in the central western coast of North America and the central western coast of Chile are suitable for the occurrence of *H. destructor*. The North American mite fauna is relatively well known, but there is no record of *H. destructor* there. Chile is the only climatically suitable place that has not been explored for *H. destructor* and its natural enemies. It is possible that Chile is actually the country of origin of *H. destructor*. There are many cases in which a pest species was named and described because it was pest in a country into which it had been introduced, but its place of origin was actually elsewhere, especially South America. Two examples are the cassava mealybug (Löhr *et al.* 1990) and Chinese wax scale (Qin *et al.* 1994).

Discussion

The pest status of *Penthaleus* n. sp. 1 has not been assessed. It is important to determine whether this species actually causes significant damage to pasture. *P.* n. sp. 1 and *P. major* appear to occur together in New South Wales. They differ morphologically when examined under a microscope, but are almost indistinguishable in the field. More study is needed to determine the geographic distribution of this new species and its importance to the pasture industry. Furthermore, recent data has shown that the species known as *Penthaleus major* actually consists of a series of asexually reproducing clones (Weeks *et al.* 1995). It remains to be seen how many of these are pests and whether they can be separated morphologically. It is also apparent from the literature that published data on '*P. major*' probably refers to more than one species (e.g. André 1932, Narayan 1962).

Wallace and Mahon (1971) indicated that the northern and western distribution limits of *H. destructor* in Australia agree closely with the 205 mm isohyet for the growing season May–October inclusive. The eastern distribution limit in New South Wales agreed closely with the 225 mm isohyet for December to March inclusive. Outside these regions, the mite may occur locally and/or temporarily. Our new information on the distribution of *H. destructor* suggests that the range of the species is still slowly expanding inland, and it can be found abundantly in much drier areas than previously thought (e.g. Southern Cross, Coolgardie and Norseman in Western Australia, northern Namaqualand in South Africa). If new pastures are established in these areas in the future, this mite may also become a pest there.

There is no doubt that the long term control of *H. destructor* will rely at least in part on its natural enemies. James (1995) has shown that there is a large and diverse fauna of predatory mites in Australian pastures, and these probably play a role in regulating the species' abundance. Additional natural enemies certainly exist overseas, and one or more of these may prove to be a useful addition to the existing Australian fauna. In the absence of any definite information about its place of origin, all possibilities for the source of these natural enemies should be considered and explored, including South Africa and possibly South America.

Conclusions

i. Five species of *Halotydeus* and three species of *Penthaleus* occur in Australia, and these can be distinguished morphologically. Only *H. destructor*, *P. major*, and possibly *Penthaleus* n. sp. 1 are pests of pasture. The other species occur in native habitats and have no economic importance.

ii. Specimens of *H. destructor* from different populations in Australia do not differ morphologically or genetically.

iii. *H. destructor* is probably native to South Africa, but may also have come from South America. We recommend that, apart from South Africa, the search for natural enemies of *H. destructor* should include Chile.

Future directions

We have identified three areas that would reward further research:

i. systematic and biological study of indigenous and overseas natural enemies of *H. destructor*,

ii. determining origin (and best sources of natural enemies) of *H. destructor* and

iii. assessing the economic importance of *Penthaleus* n. sp. 1.

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The biology and behaviour of redlegged earth mite and blue oat mite on crop plants

Garrick McDonald[A], **Kylie Moritz**[A], **Eve Merton**[B] and **A.A. Hoffmann**[B]

[A] Plant Sciences and Biotechnology, Agriculture Victoria, La Trobe University, Bundoora, Victoria 3083, Australia.

[B] School of Genetics and Human Variation, La Trobe University, Bundoora, Victoria 3083, Australia.

Summary

Earth mites are one of the major deterrents to the successful establishment of winter oilseeds, particularly canola. In order to understand how crop management practices may impact on mites and their damage, we have commenced a study of the relationships between the mites and oilseed, grain legume and cereal crop plants. *Halotydeus destructor* were shown not to be attracted to lupins, wheat or oats, and their survival and fecundity were significantly lower on these than on other plant types. This suggests that such crops, particularly lupins, used in rotations prior to canola, could minimize the in-paddock infestations of mites. Preliminary screening tests for *H. destructor* resistance has also shown that some northern hemisphere varieties of *Brassica napus* are prone to significantly less cotyledon damage than local varieties. Notably, survival and fecundity of *H. destructor* on *B. napus* was low even on susceptible varieties, indicating that the species already has a level of partial resistance. On the one variety tested (Oscar), *Penthaleus major* caused only half the damage of *H. destructor*.

Introduction

Winter oilseeds are highly vulnerable to pest damage during the first weeks after germination. The most significant pest is the redlegged earth mite (*Halotydeus destructor* Tucker) although blue oat mite (*Penthaleus major* Duges), true wireworms (Fam. Elatridae), false wireworms (Fam. Tenebrionidae), cutworms (*Agrotis infusa*) and slugs are also important.

The aim of our research is to evaluate various cultural control and plant resistance options to minimize the impact of pests on the establishing crop, particularly canola (*Brassica napus*). We are, for example, interested in how different rotation sequences may affect the build up in earth mite populations prior to a canola planting.

Earth mites are regarded as ubiquitous pests of most field crops including cereals although there is anecdotal evidence that *H. destructor* has a low preference for the latter. Thus, a crop rotation sequence with wheat preceding canola should reduce mite populations, possibly to below damage threshold levels, for subsequent crops. Another pest management option for mites in winter oilseeds may be the development of resistant plant varieties. In this paper, we summarize our progress in laboratory studies of the relationships between mites and crop and crucifer weed plants. We include preliminary results from feeding/choice studies of mites on oilseed, legume and cereal crop plants, studies of *H. destructor* population growth characteristics on crop and pasture plants,

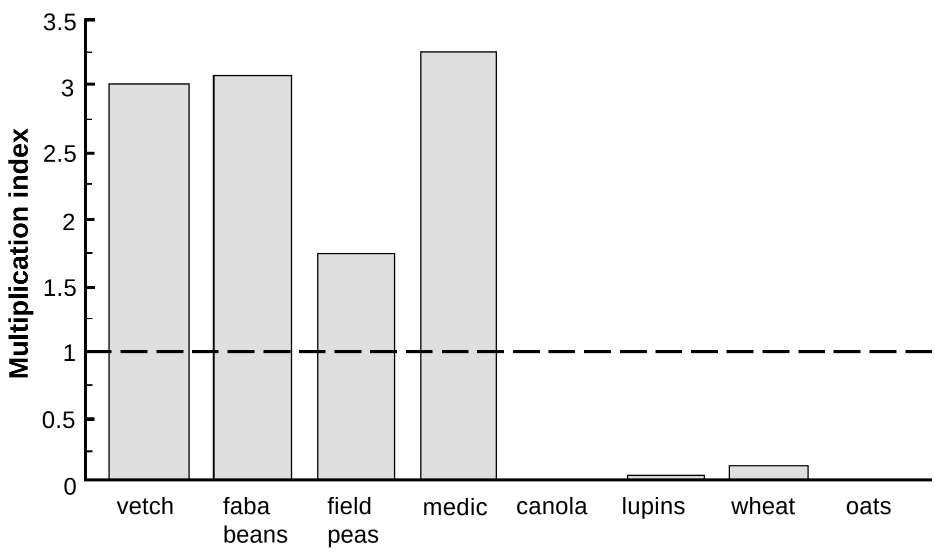

Figure 1. Net reproductive rate of *H. destructor* on various crop and pasture hosts. The dotted line indicates the net population replacement rate.