Effects of pasture pest damage and grazing management on efficiency of animal production

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Summary
Experiments at three sites in Western Australia show that grazing annual pastures to defined feed on offer (FOO) levels of 1400 and 2800 kg DM ha^{-1} can significantly reduce populations of pest insects and mites to below damaging levels. Treatment effects in spring have strong carry-over effects in the following autumn. There were no differences due to pests in pasture production except between sprayed and unsprayed set stocked treatments, and the extra dry matter produced in spring was lost over summer. Spraying to control pests did not result in increased animal production. The major effects on animal production accrued from increased pasture utilization in the defined FOO treatments. The data strongly suggest that grazing management is the major determinant of both pasture and animal production per hectare, and of populations of pest and non-pest arthropods.

Introduction
This project has its origins in the work of Wallace and Mahon (1963) and Wallace (1970). The authors concluded that severe infestations of redlegged earth mite (*Halotydeus destructor*) and lucerne flea (*Sminthurus viridis*) could cause losses in pasture dry matter production, but that the economic value of the losses was uncertain because, in general, pastures were undergrazed. Most dry matter (DM) production losses occurred in spring, when set-stocked pastures were undergrazed. Wallace and Mahon (1963) is the only work of which we are aware that attempts to quantify pest losses under grazing. Grazing intensity affects other pests (Roberts and Morton 1985) and the invertebrate fauna of grasslands (Hutchinson and King 1980). Grimm (1991) discussed the potential importance of grazing management in assessing pasture losses due to pests, including the possibility that pest populations were affected by pasture removal rate. Doyle *et al.* (1994) have reviewed the prospects for improving animal and pasture production through tactical management of pastures, such as intensive spring grazing, strip grazing, autumn deferment and nitrogen application to grass dominant autumn pastures. Pasture utilization efficiency is central to determining the value of pest control because it quantifies animal production responses to changes in amount and availability of pasture dry matter.

The project aim was to quantify relationships between pests, pastures and grazing animals. We consider the main variables to be differences between seasons and sites, and have designed the experiments so data can be compared across sites and seasons.

Methods
The main grazing experiments were located at three sites selected on average annual rainfall at South Stirlings (460 mm), Mt. Barker (640 mm) and North Dandalup (900 mm). At each site, treatments were applied in three blocks and consisted of three grazing practices, with and without pest control (total of 18 plots). Grazing treatments were feed on offer (FOO) maintained at 1400 kg DM ha^{-1} and 2800 kg DM ha^{-1} in winter and spring, and set stocked at a stocking rate considered average for the district and soil type (South Stirling, five wethers per ha; Mt. Barker, eight wethers per ha; North Dandalup, 12 wethers per ha). Pests were either not controlled or sprayed with insecticides as needed to remove *H. destructor*, *S. viridis*, blue oat mite (*Penthaleus major* Duges) and blue-green aphid (*Acyrthosiphon kondoi* Shinji). Plot sizes were such that at each site, 6–8 experimental sheep ('core' animals) were accommodated on each plot.

FOO on each plot was assessed weekly through the growing season and on the basis of these estimates non-experimental animals were added or removed to maintain target FOO. If pasture growth rates slowed to the point where FOO fell below target values, core sheep only were retained on plots. Over summer, FOO of dry pasture residues were assessed 3–4 weekly. If FOO fell below 750 kg DM ha^{-1}, plots were destocked. Pasture growth rates were estimated using exclosures usually shifted every three weeks and total annual DM production were calculated from the growth rates. Samples for digestibility and nitrogen determination were taken each time growth rate exclosures were assessed and moved. Pasture composition by density and on a plant weight basis were assessed after pasture establishment (autumn-winter) and at clover flowering (spring) by taking 15 cores at random from each plot and sorting, counting, drying and weighing clovers, grasses and forbs. Clover seed bank changes were assessed by cleaning seed from 15 cores per plot taken in spring at clover flowering and in summer when seeds were mature and swards dried. Annual seed production was calculated from the difference between spring and summer seed bank estimates.

Each year 1-year-old merino wethers were stratified on a live weight (LW) basis and randomly allocated to plots (n=8 per plot). Live weights were recorded every two weeks and back fat condition scores recorded every six weeks. In summer, when sheep were grazing dry residues, live weight were maintained by feeding lupins as necessary. Wool growth rate was estimated from mid-side dyebands applied 5–6 times through the year. Wool yield and length and strength were measured on staples taken from mid-side patches. Dyebands were removed prior to shearing and total fleece weights were recorded at shearing. The numbers of non-experimental sheep added or removed from plots to maintain target FOO were recorded and used to calculate 'sheep grazing days' per hectare.

Insects and mites were collected from pastures every 2–3 weeks using a suction machine based on the design of Wallace (1972) and deposited into containers with 70% ethanol. Thirty points selected at random were sampled and bulked in each plot and after cleaning and sub-sampling, were counted under a stereo microscope. The pests counted were *H. destructor*, *P. major*, *S. viridis*, *A. kondoi*, cowpea aphid (*Aphis craccivora* Koch), grass aphids (*Rhopalosiphum* spp.) and bryobia mites (*Bryobia* spp.). 'Beneficial' arthropods counted were bdellid mites (*Bdellodes lapidaria* Kramer and *Bdellodes* spp.), Poduroidea, Sminthuridae and Entomobryoidea. Isotomidae, (mainly *Cryptopygus thermophilus* Axelson) were separated from other Entomobryids. Dimethoate (400 g L^{-1}) was usually applied at 300 mL product ha^{-1} as paired sprays 14–20 days apart in autumn and spring, or as required. Multiple applications were needed to control invasion of *H. destructor*, *P. major* and *S. viridis* from adjacent plots, or to control aphid colonization in winter and spring. In 1994, alphacypermethrin (100 g L^{-1}) was added to the dimethoate sprays at a rate of 100 mL ha^{-1}, primarily to reduce grass aphid colonization and infection of grasses with barley yellow dwarf virus.

In addition to the grazing experiments, a series of ancillary experiments using mowers to regularly defoliate pastures were situated in small plots within the main grazing plots at each site. A fourth low rainfall site at Tammin (350 mm) was used for mowing experiments only. Each mowing experiment was designed to maintain a pasture mass under the mower of 1400–1800 kg DM ha^{-1}, with mowing at a cutting height of 25 mm every seven days. Harvested material was weighed, sub-sampled and dried to calculate weekly production, and hence growth rate. Pasture mass remaining under the mower was estimated every six weeks with quadrat cuts. Treatments included mowing throughout the season, mowing with spring deferment, and no mowing. Each mowing treatment was either sprayed to control pests, or not sprayed. Samples for pasture composition and seed production were taken as described previously (n=8 per plot). Pasture arthropods were sampled in autumn, winter and spring (n=20 or 30 per plot) by the methods described previously.

Data analysis for significance of treatment effects was carried out on plot mean data using analysis of variance and repeat time analysis for time series data. Transformations to normalize data were used as required. Site and season comparisons will be tested after three years data are available.

Results and discussion

The project is in the second of three years of field data collection. At one site (Mt. Barker) the experiment is in its third year. Consistent trends are emerging within the arthropod, pasture and animal data sets indicating similar effects between sites and seasons.

Redlegged earth mite

Grazing to 1400 and 2800 kg DM ha^{-1} had a highly significant effect (P<0.001) on *H. destructor* populations in spring. Mite numbers were typically reduced from 50 000 m^{-2} in set stocked treatments to <500 and <5000 m^{-2} in 1400 and 2800 kg DM ha^{-1} treatments respectively. Autumn populations in the next season were similarly reduced, indicating a highly significant effect on carry-over of aestivating eggs. Winter populations increase slowly until grazing pressure was increased to maintain target FOO levels. The indications are that *H. destructor* populations were quickly reduced by grazing. We have no clear evidence of how increased grazing pressure acts to reduce mite populations. If removal rate of pasture is the controlling factor, then it may be that at low removal rates (because pasture is growing slowly), mite numbers could increase even if FOO is maintained. Alternatively, mite numbers might be determined by the absolute amount of FOO during winter and spring. In autumn, mite numbers are dependent on aestivating eggs surviving from the previous spring, because at germination of pasture FOO may be less than 500 kg DM ha^{-1} while *H. destructor* populations are very high. Mowing reduces *H. destructor* populations to values found in equivalent grazing treatments. Insecticide treatments reduced and maintained populations at nil for most sampling dates, including the first dates in autumn before insecticide was re-applied. This reinforces the conclusion that reducing aestivating egg carry-over from spring can result in very low autumn populations of *H. destructor*.

Blue oat mite

P. major populations were generally lower than *H. destructor* and peaked at 3000–6000 mites per m^2, depending on site. Compared to unsprayed set stocked plots, grazing to FOO levels of 1400 and 2800 kg DM ha^{-1} significantly (P<0.001) reduced populations of *P. major* in spring. Reduced spring populations carried over to significantly fewer mites in autumn of next year. In contrast to *H. destructor*, control of *P. major* with paired application of insecticide was less effective at some sites and control in spring did not always suppress populations the following autumn. This was most marked on set stocked plots, since grazing reduced *P. major* populations in the other treatments.

Lucerne flea

Lucerne flea were present only on the gravel-loam soils at Mt. Barker and the loamy sands at North Dandalup. At Mt. Barker, populations peaked at 7000 m^{-2} in spring. Unlike *H. destructor* and *P. major*, the highest numbers of *S. viridis* occurred on grazed plots, particularly FOO 1400 kg DM ha^{-1}. The high spring populations carried over to high numbers in the following autumn. These patterns were not always consistent between sites and further data and analyses are needed to clarify the situation. Paired insecticide treatments did not control *S. viridis* as effectively as is the case with *H. destructor*.

Blue green aphids and cereal aphids

A. kondoi and *R. padi* populations have been low at all sites. Populations were significantly lowered (P<0.01) by grazing and insecticide. Symptoms in grasses suggest that barley yellow dwarf virus was prevalent in ryegrass and barley grass in the unsprayed set stocked plots. Since grasses comprise a significant proportion of pasture dry matter production, the possible effects of aphids (and other pests) on grasses needs to be considered. Wallace and Mahon (1963) found that webworm (*Hednota* spp.) and cutworm could have significant effects on pasture production. The addition of alphacypermethrin in the insecticide treatment should control these pests.

Bdellid mites

The introduced predator of *S. viridis*, *Bdellodes lapidaria* Kramer and native *Bdellodes* spp. were present at all sites, including South Stirlings where no *S. viridis* are present. Dimethoate applications, and latterly alphacypermethrin applications, did not appear to have permanent depressive effects on bdellid populations, particularly on set stocked plots where populations are greatest. Grazing to FOO of 1400 and 2800 significantly (P<0.01) lowered populations. It is likely that removal of prey through insecticide application effects may be the main reason for bdellid mite population fluctuations, rather than direct mortality from insecticides (P. Michael, unpublished data). In controlled grazing plots, decreases in bdellid numbers may have been due to reduced prey densities, or the direct effect of grazing. There were indications that *B. lapidaria* may have been exerting significant control of *S. viridis* at some sites in some years, though further work is required to substantiate this conclusion.

Poduroidea

While no attempt was made to separate species, the majority of podurids appeared to be *Hypogastrura* sp. and *Brachystomella* sp. Poduroidea were by far the most numerous of the collembolan fauna, with peak populations of 140 000 m^{-2}. Insecticides at times significantly (P<0.001) depressed populations below unsprayed treatments, but numbers recovered rapidly and at times rose above those recorded on unsprayed plots. Grazing to FOO levels of 1400 and 2800 kg DM ha^{-1} significantly (P<0.001) reduced populations. Significant variation through time (P<0.001) occurred at all sites. We suspect that the major regulator of populations was available food, determined by the amount of decaying plant material.

Entomobryidae, Isotomidae and Sminthuridae

These collembola were less numerous than Poduroidea. Generally their populations were significantly decreased by the higher grazing pressure treatments. Insecticides significantly decreased Entomobryid populations, but significantly increased Isotomidae (notably *Cryptopygus thermophilus* Axelson) and some Sminthurids, (notably *Jeannenotia violacea* Krausbauer). Food supply originating as dead plant material was likely to be the major regulator of populations. We have no indications of the niches occupied by the various collembola, or their importance in organic matter turnover.

Pasture production

To date there are no differences in total pasture dry matter production between sprayed and unsprayed treatments from plots grazed to FOO levels of 1400 and 2800 kg DM ha^{-1}. Differences of 1000–2000 kg DM ha^{-1} were recorded on set stocked plots as a result of pest control, but this extra production was lost over summer, with no benefit to animal production. Clover plant densities were higher on controlled grazing plots compared to set stocked plots, but insects did not affect clover densities in 1993. In 1994 at South Stirlings, significant decreases in clover density have been recorded in unsprayed set-stocked plots. However, set-stocked treatments have significantly less clover than graze managed plots. Clover seed production was reduced in the controlled grazing treatments. At the end of spring, plots grazed to FOO of 2800 and 1400 kg DM ha^{-1} remained green for up to four weeks longer than under set-stocking. Feed quality remained high for longer under controlled grazing treatments, but there was no difference between sprayed and unsprayed treatments at each grazing treatment.

Animal production

Spraying to control pests did not change live weight gain or wool production on any of the grazing treatments. Significant increases in live weight gain per hectare and wool cut per hectare, were recorded for the FOO 1400 and 2800 kg DM ha^{-1} treatments. This reflects the higher utilization of dry matter compared to set-stocked treatments.

Future directions

A number of areas need to be addressed in future work. Strategies for controlling pests with insecticides need to be determined, such as optimum insecticide timing and the susceptibility of different pests to the same application rates. The effects of insecticides on non-pest species need to be determined, especially collembola. Finally, the control of pasture pests via grazing management needs to be integrated with other management criteria.

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