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APRIL 2010 PRIMEFACT 631 FIFTH EDITION

Wingless grasshoppers

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This publication is designed to provide general information on wingless grasshoppers.

The wingless grasshopper (*Phaulacridium vittatum (Sjöstedt)*) is a serious pest of improved pasture in the Tablelands and Western Slopes of south-eastern Australia (below latitude 26°S) to mid-western Victoria. It is also a pest in Tasmania, South Australia and Western Australia. It is generally restricted to areas with an average annual rainfall above 500 mm.

Outbreaks have been recorded in NSW since 1935, but have become more severe and frequent in the five decades to 2004. This is largely due to the expansion of improved pasture, which provides the wingless grasshopper with favourable food plants and habitats. The wingless grasshopper prefers broadleaved plants such as legumes and short, intensively grazed pastures.

Biology

Origin

Before European settlement, the wingless grasshopper lived on broadleaved plants growing amongst the leaf litter at the interface between forest and grassland.

Conditions generally favourable for wingless grasshopper are now widespread and the base population is perpetually on the threshold of exploding to outbreak densities.

Outbreaks generally occur every 5 years or so in the Western Slopes and every 8–10 years in the Tablelands. Widespread regional outbreaks occurred in 1965–66, 1979–82 and 1989–91, but every season, localised outbreaks develop in districts experiencing favourable conditions.

Environmental change continues. Acid soils exacerbate the problem by encouraging favoured food plants. Climatic change, perhaps initially subtle, will vary the favourability of some regions for wingless grasshoppers, resulting in a greater frequency of outbreaks in some regions and a decline in others. Habitat destruction will continue to reduce the distribution of parasitoids.

Life cycle

Egg stage. Egg pods containing about 12 eggs are laid in the soil at a depth of approximately 2 cm. The eggs are insulated from the extremes of temperature at the soil surface by a froth plug. Eggs are laid between mid-summer and early autumn. Eggs undergo some development before over-wintering in a dormant stage (diapause). Development resumes with the return of warm conditions in early spring. Up to 30% of the eggs may be parasitised by two scelionid wasps (*Scelio improcerus and S. parvicornis*).

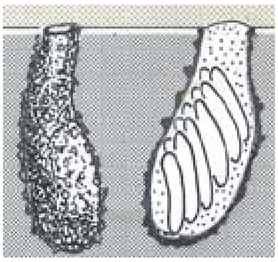

Figure 1. Wingless grasshopper egg pods (3x actual size).

The density of the egg pods, and consequently hopper density after hatching, is determined by the number of adults in the previous generation, the frequency of laying and the availability of laying sites. Favoured laying sites are small bare areas,

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most frequently found on the crests of ridges, especially following prolonged dry periods or overgrazing.

Hatching. Eggs hatch in the Northern Tablelands in October and in the Southern Tablelands in November, but localised differences in soil temperature due to vegetative cover, aspect and slope can result in erratic hatching. On bare north-facing ridges, hatching is usually early and synchronised, but on well-vegetated flats it is often late and protracted.

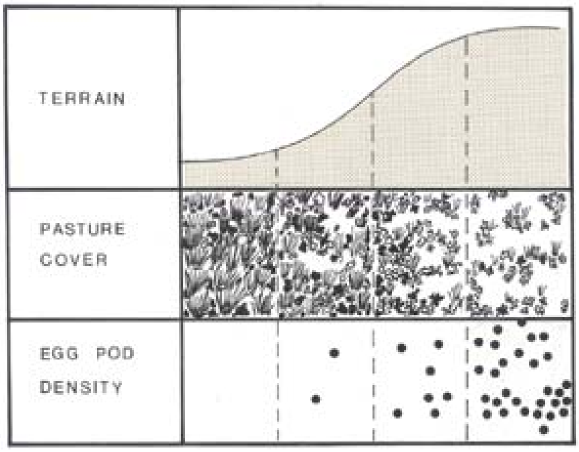

Figure 2. Terrain, pasture and egg pod density

Hopper development. Hoppers develop through five instars in approximately seven weeks before fledging to the adult stage.

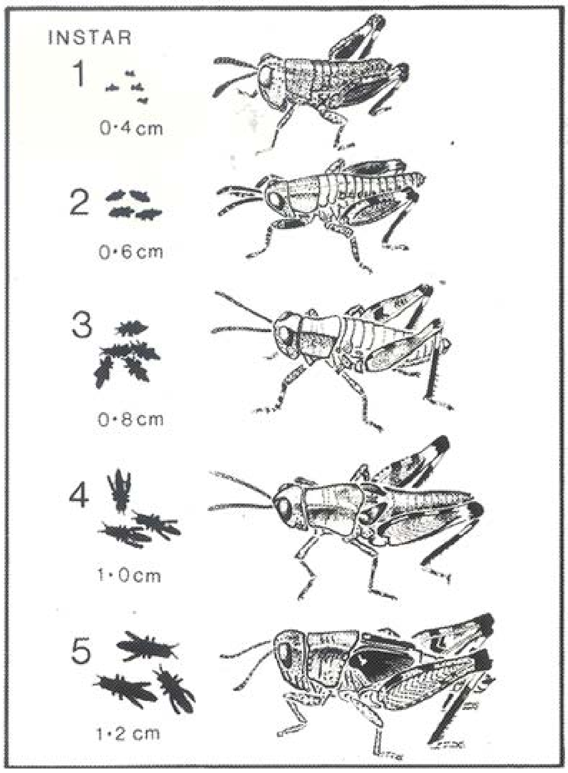

Figure 3. Growth stages of a wingless grasshopper.

1st instar, 14 days

2nd instar, 7 days

3rd instar, 7 days

4th instar, 14 days

5th instar, 7 days.

The first instar feeds on prostrate and rosette-forming plants in the lower storey of a pasture. Their survival is high during dry springs or when pasture cover is low and broadleaved food plants are abundant.

Late instar hoppers can disperse away from hatching areas, especially if there is inadequate food because of high densities or deteriorating pasture conditions.

Instars differ in their susceptibility to biocontrol agents and insecticides so it is important to know the stage you are dealing with.

Fledging typically occurs in mid-December in the Northern Tablelands, Western Slopes and Hunter Valley and over the Christmas – New Year period in the Central and Southern Tablelands.

Adults. Adults may remain in substantial numbers until late March or April. A natural post-laying decline normally starts in early March but may be postponed if dry conditions inhibit egg laying.

Other species. Other species that co-inhabit the tablelands regions include: Yellow-winged locust (*gastrimargus musicus*), Eastern plague grasshopper (*oedaleus australis*), Yellow-bellied grasshopper (*praxibulus spp*. – P.*duplex*, P. *insolens*, P. *exsculptus* and P. *laminatus*), Mountain brown (*Brachyexama lobipennis*) and Small plague grasshopper (*Austroicetes spp*.- A. *pusilla*, A. *vulgaris* and A. *cruciata*). The Australian plague locust (*Chortoicetes terminifera*) is an occasional invader – this species was widespread through the tablelands during the 2004–05 Australian plague locust outbreak).

Colour pattern polymorphism

Identifying grasshoppers during outbreaks is often difficult due to the numerous species present and the many forms (morphs) of wingless grasshopper.

Adult wingless grasshoppers vary in appearance. Males are much smaller than females; the majority (>60%) have non-functional short wings, but a variable proportion have functional long wings; approximately 6% of both sexes have a white lateral body stripe.

Behaviour

Dispersal. Instars 1 through 3 move little from their place of hatching, and 'fizzing' concentrations may persist at the hatching site for up to three weeks, especially under rank pasture conditions. Instars 4 and 5 are capable of migration and may exhibit gregarious behaviour and march in streaming bands. Gregarious behaviour is a function of high density, low food availability and hot, dry weather conditions.

When the condition of pasture deteriorates, usually first apparent on the crests of ridges, populations disperse downhill and may concentrate (densities >200/m^2) on moist flats and springs. Following rainfall, populations may undertake a reverse migration back to suitable egg laying sites on the crests of ridges.

If control of the wingless grasshopper is necessary, it should be done against concentrated populations of either third instar nymphs on the ridges prior to dispersal or adults on the flats prior to any reverse migration to the ridges.

Flight. The proportion of long-winged adults in a population of wingless grasshopper is a function of the proportion of the population with genes for long wings (genetic potential) and the intensity of environmental pressures inducing expression of these genes. The environmental pressures considered important are density and temperature – high density under hot conditions will induce, on fledging, long wings in the majority of those grasshoppers with the genetic potential.

Long-winged adult wingless grasshoppers are extremely active and migrate at the first available opportunity following fledging. Re-invasion of treated areas by long-winged adults is one of the major drawbacks to successful control in pasture during regional outbreaks.

Preceding flight they climb trees, fence posts and tree stumps, etc. to gain an elevated position, and when temperatures exceed 25°C may spontaneously fly downwind at a height of 10–50 m. Flights are usually less than half a kilometre but may result in substantial downwind displacement of populations. Outbreaks are initiated by grasshoppers migrating from primary 'hot-spots'.

Reproduction

The productivity of a generation depends on the number reproducing, their fecundity, the frequency of laying and the duration of the laying period. A five-fold increase between generations is typical under favourable conditions.

Mating occurs within two weeks of fledging, in late December, and eggs are laid from mid-January through to late March. Females lay at least three times, but under favourable conditions may lay more than six times.

The autumn break can be relied on to create conditions favourable for breeding by the wingless grasshopper, ensuring carryover to the next season.

The number of eggs in a pod is high (12–16) under favourable wet conditions and low (6–9) under adverse dry conditions. During extremely dry conditions sexual maturation may be inhibited, or if eggs have already formed they may be resorbed.

Damage

The wingless grasshopper is a severe pest of improved pasture. It preferentially feeds on the legume component, and this may change the species composition of the pasture. Newly established pastures can be damaged so severely that re-sowing is necessary. In established pastures, seed set by late-maturing clovers (e.g. strawberry and white) may be prevented. However, sub clover seed set is seldom affected.

Wingless grasshoppers compete directly with livestock for the available pasture. The extent of the competition is proportional to their density. In low summer rainfall areas it has been estimated that a density of 30/m^2 consumes 2.6 dry sheep equivalents (dse), reducing carrying capacity by 20%. In high summer rainfall districts, peak outbreak damage has been estimated over brief periods at 10 dse, or a 75% reduction in carrying capacity.

After vegetation dries off in mid-season, or food sources are exhausted, dispersal may result in severe damage to crops. This dispersal frequently results in the invasion of:

- low-lying green flats, especially if irrigated
- fodder crops such as lucerne, turnip and canola
- horticultural crops and orchards
- home gardens.

During outbreaks, a lack of pasture may result in feeding on trees. Mature trees may be defoliated up to a height of 5–10 m. Species attacked include native trees and shrubs and exotic ornamentals such as poplars and pines. Repeated defoliation makes it difficult to establish young trees under outbreak conditions, and any tree planting projects are best postponed until non-outbreak periods.

Ecology

The distribution and abundance of the wingless grasshopper is the result of the sequential action of many factors. On a regional scale, distribution is the result of a preference for a specific temperature regime. Within this range it is restricted to districts where the seasonal availability of favoured food plants is reliable. Within these districts, variation in abundance is largely influenced by seasonal variation in activity by parasites or the seasonal availability of food plants.

Region

Temperature range. The wingless grasshopper is adapted to cool temperate conditions. It only occurs in temperate regions and is restricted to the ranges in the north, but its distribution extends to the Western Slopes in cooler, more southerly locations. In South Australia and south-eastern Western Australia it is distributed in plains country.

Seasonal rainfall regimes. Wingless grasshoppers are well adapted to high summer rainfall regions of south-eastern Australia. However, in low rainfall regions the adverse impact on the wingless grasshopper numbers of low summer rainfall has been offset to some extent by the introduction of drought-tolerant pasture species such as lucerne which are also favourable food plants. Formerly inhospitable districts have also been made suitable for the wingless grasshopper through the spread of weeds such as Paterson's curse.

District

Climatic conditions. Seasonal variations in climatic conditions indirectly influence the abundance of the wingless grasshopper through its impact on the quality and abundance of food plants and the activity of parasites. It is parasites, particularly nematode worms, that account for seasonal fluctuations in the abundance of wingless grasshoppers in tableland districts.

Soil type. Light, shallow, sandy granite soils with poor moisture retention properties favour wingless grasshopper, as they are unfavourable for nematodes, and often have bare patches which are used for egg laying by the wingless grasshopper. Basaltic and other heavy soils which generally retain moisture are less favourable for wingless grasshopper, being more favourable for nematodes, and usually also supporting a good vegetative cover which restricts egg laying.

Terrain. Ridges have higher run-off (lower effective rainfall) and are less favourable for nematode parasites than flats.

Pasture composition. Wingless grasshoppers favour improved legume-based pastures. It is less of a pest in old grass-dominant pastures where the parasites have reached equilibrium with their host.

Stock type and stocking rate. Wingless grasshoppers prefer short open pastures grazed by sheep. Overgrazing exacerbates the situation by keeping the pasture short and promoting broadleaf weed invasion.

Habitat

The population dynamics of the wingless grasshopper may change even across a paddock. Sites differ in their favourability to wingless grasshopper in respect of three factors:

Availability of favoured food plants. Especially important are legumes and broadleaved weeds.

Suitability for parasites. Parasites often have narrow habitat preferences. Nematodes are most abundant in moist areas such as lower slopes where run-off produces high effective rainfall, which results in frequent episodes of parasitism. Scelionid egg parasites prefer the fringe of tree clumps – the original habitat of the wingless grasshopper.

Minor differences in soil type and slope of a site and the stability of the wingless grasshopper population or the frequency of invasion may significantly affect the impact of nematodes on host abundance.

Availability of egg laying sites. Minor differences in patchiness of the plant cover may render some sites more favourable for egg-laying.

Season

The low survival of wingless grasshoppers caused by parasites may be partially offset by higher productivity in the survivors under wet conditions.

Parasites favoured by wet conditions include:

- Nematode worms:
  - *Amphimermis acridiorum*
  - *Agamermis catadecaudata*
  - *Mermis quirindiensis*
  - *Hexamermis spp*.
- Scelio egg parasites:
  - *Scelio improcerus*
  - *Scelio parvicornis*.

Parasites favoured by dry conditions include:

- Bee flies (Trichopsidea oestracea)
- Flesh flies (Blaesoxipha pachytyli).

The impact of these parasites on wingless grasshopper may be supplemented by reduced productivity in survivors under dry conditions.

Population dynamics

In the Tablelands

Survival is variable due to seasonal differences in the activity of parasitic nematodes, while productivity is relatively stable due to generally adequate food availability. The population in a given season is determined by survival in the previous season.

In the moist tablelands of NSW the population dynamics of wingless grasshopper is driven by the level of survival to the egg laying stage. The main influence on survival is the level of parasitism by *mermithid* nematodes. It is high during wet weather and low when conditions are dry.

Average seasonal conditions are characterised by stable wingless grasshopper populations – population growth only occurs following seasons of abnormal climate – abnormally dry in the Tablelands and abnormally wet on the Western Slopes.

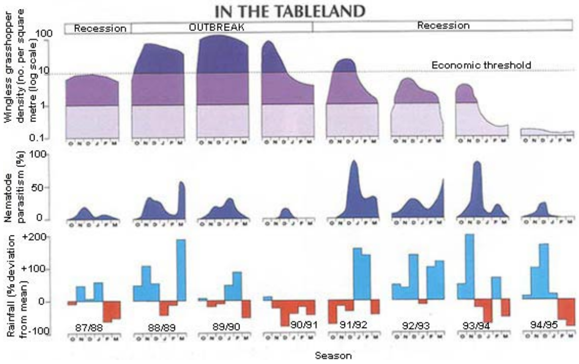

Figure 4. Long-term wingless grasshopper trends in the Tablelands

Survival is high due to lack of parasites, but productivity is variable due to the severity of midsummer conditions. The population in a given season is determined by the productivity of the previous generation.

Control

Large control campaigns, such as those carried out for the Australian plague locust, are not undertaken against the wingless grasshopper as outbreaks are generally localised. Control is at the discretion of the landholder – the landholder decides if the treatment necessary to minimise damage to crops and pasture is economically justified. In the long term the intensity of outbreaks may be reduced by changes in land management practices.

Short-term control

Pesticides. When using any pesticides always remember to follow the instructions on the label (including application rates, withholding periods, export slaughter intervals, distances, non-targets) and wear the appropriate personal protective equipment.

Aerial spraying. Broad-area spraying of pastures is not generally recommended because dry conditions typically prevail during outbreaks and any economic benefit (increased pasture growth) is doubtful. Re-invasion of sprayed pastures is also likely to occur if they improve relative to untreated pastures. Non-target organisms such as dung beetles may also be adversely affected by broad-area spraying.

Ground spraying. Extensive ground spraying is sometimes justified to protect special purpose pastures (such as lucerne, canola or turnip) and irrigated fodder crops.

Barrier treatments. The strategic location of a barrier treatment may be an option to protect vineyards, orchards, vegetable gardens, home gardens or other green crops. In placing a barrier treatment, consider that wingless grasshoppers tend to migrate in search of feed from bare ground and hill tops where they hatched.

Barriers may be formed in several ways, including the following:

- Using treated bran applied on the edge of the area to be protected or on bare earth between crops and surrounding land. Follow the directions on the label or permit (see permits.apvma.gov.au/PER12065.PDF).
- Spraying a strip of green foliage around the perimeter of the crop with a chemical registered for the purpose. In some cases, a strip of the crop itself may be sacrificed to form this barrier.

Alternative control

There has been considerable research, both overseas and in Australia, for alternatives to traditional chemical insecticides. Research has concentrated on insect growth regulators (IGRs), 'soft' insecticides (narrow spectrum and low mammalian toxicity) and bioinsecticides (fungi, viruses and amoeba). Bioinsecticides have the advantages of being host-specific, non-persistent in the environment and harmless to stock and humans. The most promising bioinsecticide is the fungus metarhizium, which has been successfully trialled against the wingless grasshopper in Australia.

Habitat modification

Species composition of pastures. Wingless grasshoppers are favoured by pastures with a high legume component. Grass-dominant pastures containing tolerant species such as phalaris are recommended for sites with a history of infestation by wingless grasshopper.

Stocking rate. Although the stocking rate is difficult to manipulate under the dry conditions which accompany outbreaks, the greater the density of pasture the less favourable it is for wingless grasshoppers.

Weed control. Deep-rooted, drought-resistant weeds (thistles, sorrels and lamb's tongue) and woody weeds (briar and blackberries) act as food sources for the wingless grasshopper under drought conditions when other food sources have withered. In the absence of these food sources very few eggs would be produced under dry conditions.

Soil acidity. A reduction in soil acidity may reduce the incidence of Sorrel sp. (*Rumex acetosella*), a favoured food plant of the wingless grasshopper.

Parasite enhancement

Erosion control. Moist areas near springs are important refuges for the nematode parasites of the wingless grasshopper. Erosion gullies lower the watertable and eliminate these refuges. On the Western Slopes, erosion control is especially important because the entire nematode population may be restricted to such locations.

Host maintenance. Cultivation temporarily renders an area unsuitable for habitation by wingless grasshopper. The temporary lack of hosts may reduce parasite populations by interrupting their life cycle. The adverse impact of cultivation on host numbers is reduced if pasture rejuvenation is by minimum tillage, is staggered and is small in scale.

All of the above medium-term control measures are also good everyday farm management practice. Their impact on the wingless grasshopper is simply another justification for their adoption.

Long-term control

The nematode parasites depend on moist conditions for egg hatching, host infection, emergence from the host and survival in the soil. Their activity is inhibited in moisture-deficient tableland habitats such as the crests of ridges and shallow porous soils. Under dry conditions these habitats reduce the numbers of parasites and allow unrestricted wingless grasshoppers to increase and spread, and they are the source of widespread outbreaks.

Where rough terrain prevents revegetation with perennial grasses, the long-term solution is reafforestation in the form of either tree conservation nature strips or commercial plantations of native hardwood/exotic softwoods. It takes approximately 6 years for a *Pinus radiata* plantation to exclude the wingless grasshopper.

Acknowledgement

This Primefact is based on Agfact AE.1 (fourth edition) written by Graeme Baker, former Senior Entomologist, NSW Agriculture.

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ISSN 1832-6668

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Job number 9958 PUB08/2[v2]