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Biological control of Paterson's curse

By Jonathan Dodd, Research Officer, Weed Science Branch and Bill Woods, Entomologist, South Perth

The long-delayed biological control programme for the weed Paterson's curse (Echium plantagineum) has begun with the release of the leaf mining moth (Dialectica scalariella), an insect slightly bigger than a mosquito. The caterpillar stage of the moth feeds inside the leaves, producing tunnels and chambers which damage the leaf.

Since late 1988, some 140,000 leaf mining moths have been released at 200 sites between Northampton and Esperance for the biological control of Paterson's curse, one of the most widespread and conspicuous toxic weeds of pastures, roadsides, reserves and disturbed land in the south-west of Western Australia.

The leaf mining moth has already become established in suitable areas. Although the familiar purple haze of Paterson’s curse will continue to be seen for years to come, we expect that the leaf mining moth - and other agents yet to be released - will make it a more manageable weed and less of a curse.

Significance of Paterson’s curse

Paterson's curse is a long established weed in the south-west agricultural areas. It is primarily a weed in pastures where it competes with desirable pasture plants without contributing significantly to forage value. It can be a significant contaminant of hay crops.

Although readily grazed by sheep, the plant is toxic and can cause poor growth, liver damage and death if enough is eaten over a long period (Seaman and Dixon, 1989).

Paterson's curse is a valuable source of nectar and pollen amongst some beekeepers, and up to one-fifth of the State's honey production comes from it.

The leaf mining moth

Description

The leaf mining moth is native to the Mediterranean, where it is one of the most common insects attacking Paterson's curse (Wapshere and Kirk 1977). The silvery-white and brown moth is a small, thin, fragile insect, slightly bigger than a mosquito. It has a slender body five millimetres long, narrow wings and thin legs. The long antennae wave rapidly all the time.
The moth can be found on the underside of Paterson’s curse leaves, on flowering stems, or flying quickly between plants. When resting, the front part of the moth’s body is raised clear of the surface.

**Life cycle**

A female moth will lay, on average, 135 eggs over a three-week period. Eggs are usually laid on the underside of rosette leaves. On flowering plants, eggs are also laid on the small leaves that grow on the stem, and on the stem itself. The newly hatched caterpillar burrows into the leaf and starts to eat a path within the leaf tissue, producing a narrow winding tunnel about a millimetre wide but up to two or three centimetres long. This tunnel is called the ‘leaf mine’.

The caterpillar feeds voraciously, enlarging the tunnel into a blister-like chamber up to two centimetres wide and four centimetres long. These chambers are formed by the caterpillar eating the tissues between the upper and lower surfaces of the leaf. Chambers are usually seen on the underside of the leaf and are the most obvious sign of the moth’s presence. (A native moth causes similar damage to Paterson’s curse but produces smaller chambers. It is not significant as a biological control agent.)

A fresh chamber is golden brown and has a glistening appearance, while old chambers are dull brown and contain the dark granular droppings of the caterpillar.

The small green caterpillar develops inside the chamber, eventually growing to about five millimetres long, before spinning a silken bag in which it pupates.

The adult moth emerges from the leaf after a few days in summer or after several weeks in winter. Under favourable, warm conditions, the moth progresses from egg to adult in two or three weeks, allowing moth numbers to increase rapidly.

**Damage**

Caterpillars destroy leaf tissue when producing tunnels and chambers. The leaves of a heavily damaged plant become distorted by the large numbers of tunnels and chambers, and have little undamaged green tissue. Because of this, the plant’s photosynthetic activity is reduced. Damaged plants are likely to be less vigorous and will probably produce fewer viable seeds. Old damaged rosette leaves are prone to fungal attack and die prematurely.

**Breeding the moths**

The moths were reared at the Department of Agriculture’s South Perth insectary. Potted plants of Paterson’s curse, which had been raised from seed or grown from seedlings transplanted from the field, were placed in cages containing 30 to 50 newly emerged moths. Female moths laid eggs on the Paterson’s curse. The caged plants were held in the insectary at 25°C. At this temperature, adult moths emerged 20 to 21 days after eggs had been laid.

A small vacuum pump was used to suck the moths gently into large plastic jars, in which they were transported to the release sites. In most cases, one or two jars - each containing 300 moths - were used at each site. During the breeding programme, 2,500 plants of Paterson’s curse were used to generate 140,000 moths.

**The initial releases**

The first releases of the leaf mining moth were made at eight sites between Gingin and Donnybrook (Table 1), chosen either because they could be irrigated or because they were likely to be sufficiently moist to enable Paterson’s curse to persist through summer. By late January 1989, the leaf mining moth had established, was breeding at five of the release sites and was beginning to spread (Table 1).
Table 1: Progress of the leaf mining moth in Western Australia (results as at January 30, 1989)

<table>
<thead>
<tr>
<th>Location</th>
<th>No. of releases</th>
<th>Dates of release (all 1988)</th>
<th>Plants</th>
<th>Moths</th>
<th>Total moths released</th>
<th>Establishment</th>
<th>Spread</th>
<th>Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane Brook</td>
<td>7</td>
<td>4/10-1/12</td>
<td>59</td>
<td>790</td>
<td>3,700*</td>
<td>Yes</td>
<td>1.6 km</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2,265)‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swan Research</td>
<td>4</td>
<td>20/10-14/12</td>
<td>25</td>
<td>600</td>
<td>1,890</td>
<td>Yes</td>
<td>55 m</td>
<td>No</td>
</tr>
<tr>
<td>Station Burekup</td>
<td>2</td>
<td>26/10,29/11</td>
<td>24</td>
<td>720</td>
<td>1,920</td>
<td>Yes</td>
<td>200+ m</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1,320)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donnybrook</td>
<td>1</td>
<td>15/11</td>
<td>20</td>
<td>-</td>
<td>1,000</td>
<td>Yes</td>
<td>25+ m</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(500)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>880</td>
<td>No</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Toodyay</td>
<td>2</td>
<td>3/11,17/11</td>
<td>12</td>
<td>280</td>
<td>600</td>
<td>No</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(580)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roleystone</td>
<td>1</td>
<td>early Dec</td>
<td>-</td>
<td>c.300</td>
<td>c.300</td>
<td>Yes</td>
<td>0 m</td>
<td>Yes</td>
</tr>
<tr>
<td>Serpentine</td>
<td>1</td>
<td>4/11</td>
<td>-</td>
<td>c.300</td>
<td>c.300</td>
<td>No</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gingin Brook</td>
<td>1</td>
<td>early Dec</td>
<td>-</td>
<td>c.300</td>
<td>c.300</td>
<td>No</td>
<td>-</td>
<td>No</td>
</tr>
</tbody>
</table>

* Assumes 50 moths per plant.
‡ Assumes 25 moths per plant.

The most successful release has been at Jane Brook in the Swan Valley, where nearly 4,000 moths were introduced. To ensure a continuity of Paterson's curse, the site was irrigated twice a week from January to March 1989. The weed germinated as soon as irrigation began, resulting in a dense stand of rapidly growing plants, upon which the moth proliferated. Irrigation might not have been necessary, however, since appreciable numbers of Paterson's curse rosettes and flowering plants survived through summer on firebreaks, road verges and in horse paddocks near the release site. In addition, occasional heavy rain from February onwards caused extensive germination of Paterson's curse and vigorous growth of the resulting seedlings.

The combination of a high population density of the moth at the release site, high temperatures which allowed the moth to breed rapidly and an abundance of Paterson's curse throughout the Swan Valley provided ideal conditions for the spread of the moth. By late January 1989, the moth had spread up to 1.6 km (see map) and by April plants at the Jane Brook site were heavily damaged and supported large numbers of caterpillars and moths.

About 300 moths per plastic jar were taken to suitable sites and released.

Undamaged (left) and heavily damaged flowering plants of Paterson's curse growing at Jane Brook.
By mid May, infested plants were found throughout the Swan Valley from Ellen Brook to Guildford, as far as 12 km north and 7 km west of the release site (see map). Within eight months of its release, the leaf mining moth had spread throughout the Swan Valley and could be found wherever Paterson's curse grew. The moth has also spread into the nearby foothills of the Darling Scarp and over the scarp towards Gidgegannup, where infested plants have been found 30 km north-east of the Jane Brook release site.

Establishment at other sites
The moth established and persisted at the Swan Research Station and Burekup on Paterson's curse plants that survived the summer without irrigation (Table 1). At Donnybrook, the moth established on both irrigated and non-irrigated plants. At these sites, the moth spread up to 300 m by mid 1989, although the population at Burekup was destroyed by grazing during the summer.

At Roleystone, the moth established on plants that were growing on a leach drain, but no spread occurred because there were no other live plants nearby.

At the other sites (Table 1), the moths failed to establish because the Paterson's curse died from lack of moisture shortly after the moths were released. Follow-up releases were made at these sites in autumn 1989.

In the Swan Valley, at least, the leaf mining moth appears to be a promising agent for the biological control of Paterson's curse. However, the moth needs a continuous supply of the weed throughout summer, both as a food source and for breeding, since unlike many other insects it does not have a summer resting stage. Provided there are live plants present over summer, the moth will breed rapidly and spread widely, detecting and infesting plants of Paterson's curse, whether growing as isolated individuals or in dense stands. Dense populations of the moth can cause a lot of leaf damage, leading to premature leaf death.

Release policy
Encouraged by the results from the initial releases, we decided to release the leaf mining moth over a wider area.

During autumn and winter 1989, over 140,000 leaf mining moths were released at 200 sites in 50 shires within an area bounded by Northampton, Mukinbudin, Esperance and Nannup. Agriculture Protection Board field staff selected 90 per cent of the sites and released moths at those sites. In most cases, moths were released where Paterson's curse would be likely to survive through summer, such as on seepage areas, along creek lines and beside dams.

In most situations where Paterson's curse is a broad-acre weed, environmental conditions do not permit the weed - and hence the moth - to persist over summer. Even so, the highly mobile moth should be able to locate those occasional habitats where over-summering might be possible. If this occurs, the moth might spread from these refuges each year and re-invade the surrounding areas.

Monitoring
The progress of the leaf mining moth is being followed at selected release sites. Also, intensive monitoring has begun at a site at Muresk Institute of Agriculture, in the heart of the heavily infested Avon Valley, under a collaborative programme with Institute staff and the CSIRO Division of Entomology. At this site, detailed observations are being made of the progress of the leaf mining moth and the response of Paterson's curse.

Establishment
Surveys conducted by Agriculture Protection Board field officers in October 1989 revealed that the moth had survived the winter and had become established at about 35 per cent of the release sites (to late October 1989).

Future developments
As well as the leaf mining moth, CSIRO identified several other insects in southern Europe during the 1970s as potential biological control agents for Paterson's curse (Table 2).

Between them, these insects attack all parts of the plant - from the root to the flowering stem - at all stages of plant growth from the seedling to the flowering plant. Importantly, all the insects other than Dialetica have a summer resting stage which enables them to survive the months when there is usually no live Paterson's curse. This feature makes these insects highly attractive for use in Western Australia.
Recent research by CSIRO in Europe has found a number of other insects that are being investigated as possible biological control agents. Two of these 'new' insects are species of *Ethmia*, a moth whose caterpillars destroy the buds and flowers of Paterson's curse. Caterpillars of one of the *Ethmia* species also feed at the centre of the rosette, damaging leaves and preventing stem production.

There are also two species of the beetle *Meligethes*, which feeds on the pollen of Paterson's curse, and a species of midge (*Asphondylia*) whose larvae convert Paterson's curse flower buds into infertile galls. Field surveys in Portugal have detected damage by a mite which could have potential as a biological control agent.

Provided these species satisfy the strict quarantine requirements that govern the importation and release of biological control agents in Australia, we can expect that a succession of agents will be released over the next few years for the biological control of Paterson's curse. The next agent likely to be released in Western Australia is the root boring weevil, *Ceutorhynchus larvatus*, whose larvae feed on the root crown and leaf stalks of Paterson's curse rosettes (Delfosse and Cullen 1985). This agent could be released in 12 to 18 months.

**Table 2. Insects approved for use as biological control agents for Paterson’s curse**

<table>
<thead>
<tr>
<th>Agent</th>
<th>Part attacked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf mining moth</td>
<td>Dialectica scalariella</td>
</tr>
<tr>
<td>Root boring weevil</td>
<td>Cestorhynchus larvatus</td>
</tr>
<tr>
<td>Root boring weevil</td>
<td>Cestorhynchus geographicus</td>
</tr>
<tr>
<td>Flea beetle</td>
<td>Longitarsus aeneus</td>
</tr>
<tr>
<td>Flea beetle</td>
<td>Longitarsus echii</td>
</tr>
<tr>
<td>Sap sucking bug</td>
<td>Dictyla echii</td>
</tr>
<tr>
<td>Sap sucking bug</td>
<td>Dictyla nasussa</td>
</tr>
<tr>
<td>Stem boring beetle</td>
<td>Phytoecia coerulescens</td>
</tr>
</tbody>
</table>

* Subject to passing quarantine requirements

**Acknowledgements**

We thank Phil Lawrence and Paul Hutchinson, of the Department of Agriculture's South Perth Insectary for their expertise in rearing and harvesting moths. Sandy Lloyd and Patrick Walsh provided excellent technical assistance with all aspects of the programme. We also thank the large number of Agriculture Protection Board field staff who selected sites and released the moth.

**References**


