A history of biological control of *Lantana camara* in New South wales

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Summary

All of the 23 species of insects introduced into Australia since 1914 for biological control of lantana are reviewed. Fifteen species have become established but only four are sufficiently populous to exert suppression on lantana in New South Wales. The most successful are the leaf-mining beetles *Octotoma scabripennis* and *Uroplata girardi* which are now common over a large part of north-eastern New South Wales. The full potential of these and other later introductions is still at least 20 years away. Fresh introductions of insects adapted to temperate climates and shaded habitats are needed.

Introduction

At least two distinct species of Lantana are recorded as naturalized in Australia (Swarbrick 1986). These are *Lantana camara* L. *sensu lato*, and *L. montevidensis* (Spreng.) Brig., the latter usually called "Creeping Lantana" (Henderson 1969). The importation of insects to control lantana has been primarily aimed at the *L. camara* complex.

Twenty nine taxa of *L. camara* are listed (Smith and Smith 1982) as naturalized in eastern Australia. Of these, nineteen are sufficiently common to be of economic importance either as weeds or poisonous plants. Eight taxa have been recognized as naturalized in New South Wales. Of these the "Common Pink" taxon is the major weed. It ranges from Ulladulla northwards into Queensland and west to the Great Dividing Range. The other problem lantana in New South Wales is "Common Pink-edged Red" which occurs mainly in the north but can be locally abundant as far south as Kurrajong, west of Sydney. "Common Pink-edged Red", being poisonous, is a major problem on cattle properties in the Kempsey District. "Common Pink", though not poisonous, is much more widespread and adaptable causing problems in forest, agriculture, parks and suburban areas.

L. camara, a native of tropical and subtropical America, was introduced into Australia in the early 19th century, probably as garden ornamental cultivars, from a number of sources. Swarbrick (1986) indicates that *L. camara* was recognized as a troublesome weed in Queensland and New South Wales before 1890 and by 1919 had been declared a noxious weed in 18 municipalities and 22 shires.

Exotic weed plants usually arrive without their natural herbivores and other pests and pathogens. The aim of biological control is to import some of these natural enemies to provide a self-sustaining reduction in the target weed plant's growth and spread. In southern Brazil, where lantana is native, Winder and Harley (1983) observed that insects feeding on the fruits, seeds and vegetative parts of the plant effectively restrict its growth and dispersal.

L. camara has the distinction of being the first weed against which biological control was attempted. In 1902, the Hawaiian Sugar Planters' Association commissioned the entomologist Albert Koebele to collect lantana insects from Mexico. As a result, 23 species of lantana insects were sent to Hawaii. Of these a total of eight became established to the extent that there was a "diminishing effect" on the lantana on some of the islands (Perkins and Swezey 1924). Further introductions have since been made so that lantana has been brought under control over much of its range in Hawaii (Harley 1973).

The Hawaii experience prompted the first introductions of lantana insects into Australia. These importations began in 1914 and continued, with some long inactive periods, up to 1981. It was not until 1956 that New South Wales took an active part in the rearing and distribution of lantana insects.

Introductions pre 1936

The first introductions of lantana insects into Australia were 1914 to 1917 when the Queensland Department of Agriculture and Stock imported four species from Hawaii. These were a moth species *Epinotia lantana* (Busck) (Tortricidae), a butterfly *Strymon bazochii* (Godart) (Lycaenidae), and two fly species *Eutreta xanthochaeta* Aldrich (Trypetidae) and *Ophiomyia lantanae* (Froggatt) (Agromyzidae). *E. xanthochaeta* is a gall former and the others specifically feed on the flowers and fruit.

The most significant of these first introductions is *O. lantanae*. This small agromyzid fly is now widespread in New South Wales where it infests a large proportion of the lantana fruit. In the Sydney area it has been observed that the adult flies are most abundant during February and March. Infestation, while not harmful to the plants themselves, renders the berries unpalatable to birds (Perkins and Swezey 1924) so that seed dispersal to uninfested areas is reduced. *E. lantana* is also established (Common 1957) but this insect is of minor importance. The other two species failed to become established (Wilson 1960).

Harley (1973) listed a fifth species, a moth *Lantanophaga pusillidactyla* (Walker) (Pterophoridae), as being introduced about this time. It established but remains of minor importance (Harley 1971).

After the initial introductions there were no more until 1935-36 when the Council for Scientific and Industrial Research introduced *Teleonemia scrupulosa* Stal. (Tingidae) from Fiji. This sap-sucking bug had been introduced into Fiji in 1928 from Hawaii having originated from Mexico in 1902 (Fyfe 1937).

In Australia *T. scrupulosa* became established and is now regarded as an important control agent (Winder and Harley 1983). Disadvantages are its preference for certain taxa and dislike of unusually wet or cold conditions (Harley and Kassulke 1971). The damage caused by this bug is somewhat sporadic but when it occurs in large numbers severe defoliation results. In New South Wales "Common Pink-edged Red" lantana has been severely defoliated in the Toorooka-Willi Willi area, west of Kempsey. However, the periods of high population do not occur every year and the plants often recover. In this same area the "Common Pink" taxon is not seriously affected by *T. scrupulosa* even when growing among heavily infested "Common Pink-edged Red" lantana.

Post 1956: a new beginning

In 1953 an expedition to Central and South America led to further introductions of lantana insects into Australia. This expedition was carried out by Mr. N Krauss of the Hawaiian Territorial Board of Agriculture and Forestery, and Mr. J. Mann of the Queensland Department of Lands. As a result of these investigations selected lantana insects were sent to Hawaii for propagation and host preference testing (Krauss 1962). Subsequently about half of the species evaluated were brought from Hawaii to Australia.

Up to this time New South Wales had not actively participated in the biological control of lantana. All quarantine assessment and rearing work in Australia had been carried out near Brisbane. In 1958, however, the Forestry Commission of New South Wales began to take an active role in the mass rearing and release of lantana insects because of the problems caused by lantana in State Forests, notably the annual expense of keeping fire trails clear. It was estimated that in 1961, 138,000 ha of State Forests and about 300,000 ha of agricultural land were infested with lantana.

Queensland Department of Lands Introductions

Three moth leaf eaters were brought into Australia in 1956. These were *Neogalea esula* (Druce), *Diastema tigris* (Guen.) (Noctuidae), and *Salbia haemorrhoidalis* (Guen.) (Pyralidae).

Upon release from quarantine (at Sherwood in Qld.) of *N. esula* and *S. haemorrhoidalis* the Forestry Commission of New South Wales obtained a breeding stock and the mass rearing of these two species began in New South Wales. Despite problems with disease, sufficient numbers were released in 1958-1960 to ensure that both species became widely established in New South Wales. However, they failed to develop dense populations, being seriously checked by native parasites and predators (Willson 1968, 1979b). Consequently, the damage inflicted on lantana by these two species is not significant. The third species, *D. tigris*, was never reared in New South Wales because of the difficulty of establishing a breeding stock.

In 1965 an African strain of *Hypena strigata* (F.) (Noctuidae), a leaf-feeding moth, was brought in via Hawaii by the Queensland Department of Lands. Subsequently this species was found to be already present in Australia (Julien 1982). The African strain was reared for one year and widely released but with little apparent increased effect.

During the early years of Forestry Commission participation the insect rearing work was carried out in various locations. From 1967 this was centralised to a specially built laboratory at Cumberland National Forest.

First Joint Venture Introductions 1966 - 1967

From 1964 C.S.I.R.O joined with Department of Lands Queensland to evaluate and introduce more Lantana insect species into Australia.

The leaf-mining beetles *Octotoma scabripennis* Guerin-Meneville and *Uroplata girardi* Pic. (Chrysomelidae), and the stem-boring beetle *Plagiohammus spinipennis* (Thomson) (Cerambycidae) were introduced in 1966 from Hawaii where they had been introduced following the Krauss and Mann expedition of 1953. Successful establishment in Hawaii prompted their introduction into Australia following assessment testing carried out by CSIRO (Harley 1969a, 1969b; Harley and Kunimoto 1969).

The two leaf-mining beetles *O. scabripennis* and *U. girardi* were first introduced into New South Wales in November 1966. The first releases, made in January 1967, were in northern areas of the State from stocks reared by the Queensland Department of Lands. At this time, cage rearing was also commenced in Cumberland National Forest.

In Queensland the leaf miners quickly became established around the Brisbane area and by May 1967, it was possible for small field collections to be made. The beetles were successfully reared at the Cumberland National Forest Laboratory but much more slowly than was possible in Queensland. During the period 1967 to 1969 a combined total of 4000 adults of both species were released in New South Wales. Most of these were from Queensland Department of Lands field collections around Brisbane. It soon became obvious that they were more climatically suited to northern New South Wales and Queensland where they are now established major pests of lantana (Winder and Harley 1983).

During the period 1970 - 1972 four expeditions were made to the Brisbane area where Forestry Commission staff collected a total of 137,000 beetles. The percentage of each species was 44% *O. scabripennis* and 56% *U. girardi*.

After 1973 these field collections were made by the Queensland Department of Lands. Between then and 1984, 11 annual collections were made totalling 771,000 beetles. Both species occur together in the Brisbane area and for this reason were always collected together. Altogether almost one million beetles of these two species have been released in New South Wales and they are now widely established in north eastern New South Wales and in discrete areas as far south as Sydney. The area of blanket establishment is continuous from the Queensland border 160 km south to Grafton and west 100 km from the coast to the Rocky River near Malara State Forest (Fig. 1).

Distribution of the two species appears to be determined by site conditions. In New South Wales *U. girardi* is the more widespread and successful species and is often present in quite large numbers on physiologically stressed lantana. Observations by the author, in August 1985, showed *U. girardi* to be common north west of Grafton on water stressed or fire or herbicide injured lantana; *O. scabripennis* is always scarce in such conditions. The most southerly infestation of *U. girardi* in New South Wales is the Palm Beach area of Sydney.

In some areas only *O. scabripennis* occurs, e.g. Oyster Bay and Newport near Sydney. The Newport population is always large, while that at Oyster Bay is small to medium; both infestations have been stable for some years. The most western of the leaf miner infestations in New South Wales, at Rocky River, seems to be composed only of *O. scabripennis*.

In Queensland both Harley (1973) and Willson (1979b) have noted that wherever high populations of these leaf miners occur lantana is receding. The effect of *U. girardi* and *O. scabripennis* on infested lantana in New South Wales has not been assessed apart from field observations. These observations indicate there is no dramatic decline up to the present. However, it is apparent that the full potential of these leaf miners is still some years away.

In Australia, these leaf miners appear to be relatively unaffected by parasites but there are some predators. Liddy (1982) found that silvereyes (*Zosterops lateralis*) feed on *U. girardi* in south-eastern Queensland. Bird damaged larval mines have been

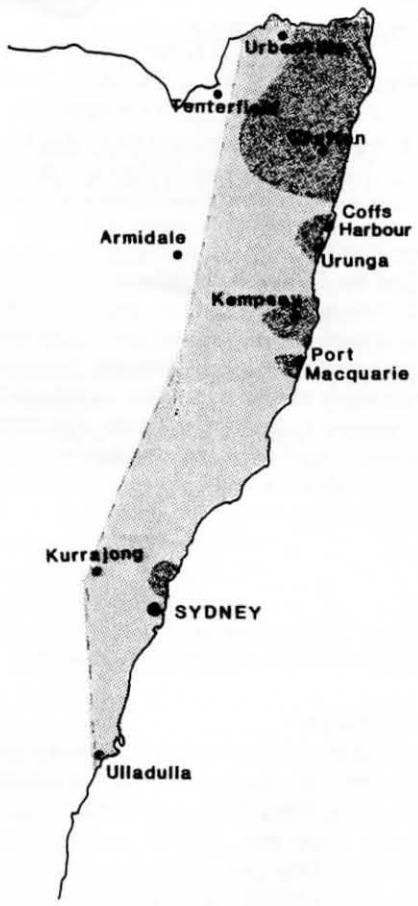

Figure 1. Distribution of *Lantana camara* in New South Wales. The darker shading indicate areas of *Octotoma scabripennis* and *Uroplata girardi* establishment.

observed in Cumberland National Forest, however, the bird species has not been identified. Bulldog ants (*Myrmecia* spp.) are non-selective predators and have been observed carrying adult *O. scabripennis*. Spiders, including *Diaea* sp., *Theridion* sp., and *Uloborus* sp., have also been observed to take adults of both species. *O. scabripennis* is the most vulnerable to predation in the adult stage because it remains on open leaf surfaces. *U. girardi* are protected by leaf edge curl caused by their feeding activity. It is likely that predation has little effect on large populations but could be significant during establishment of these leaf mining beetles.

The stem-boring longicorn beetle *Plagiohammus spinipennis* was first brought into New South Wales, from the Queensland Department of Lands as a breeding stock, in June 1967. Attempts to rear this insect were unsuccessful until the artificial diet technique (Harley and Willson 1968) was adopted sucessfully in February 1968 (Hadlington and Johnson 1974).

From 1969 to 1981 22,000 longicorns were reared to the adult stage and widely released in New South Wales. *P. spinipennis* has become established on "Common Pink-edged

Red" lantana but unfortunately "Common Pink" has proved to be resistant.

P. spinipennis kills individual stems of lantana by ringbarking them, usually up to 100 mm above ground level. The light to medium infestation most recently observed at Willi Willi, about 50 km west of Kempsey in "Common Pink-edged Red", results in only one or two stems per bush being killed each season. This level of damage is not significant is its own but coupled with the occasional heavy *T. scrupulosa* infestations it appears to prevent existing lantana areas from expanding.

CSIRO Introductions 1969-1972

In 1969 CSIRO brought three new species of tingid bugs into Australia directly from South America. These were *Leptobyrsa decora* Drake, *Teleonemia elata* Drake, and *T. harleyi* Froeschner (Harley and Kassulke 1971, Harley and Kassulke 1973). In 1972 another tingid, *T. proxlixa* (Stal.), also from South America, was introduced (Harley and Kassulka 1975). After host testing under quarantine all four (species) were approved for release. A fifth tingid (*T. validicornis* Stal.) was tested in Australia but not released because it failed host specificity trials (Harley and Kassulke 1974b). Additional biotypes of *T. scrupulosa* were introduced from widely scattered geographic locations within its indigenous range, and a further attempt was made to establish the gall fly *Eutreta xanthochaeta* (Harley 1973).

Of the new introductions only *L. decora* was reared in New South Wales. The *Teleonemia* species have a very limited potential in this state because of their rather specialized feeding preferences (Harley 1973). Moreover rearing and retention of cultures is difficult.

L. decora was first received in New South Wales in April 1970. During the next 5-years it was intensively reared at the Cumberland National Forest Laboratory in both inside and outside cages almost exclusively on "Common Pink" lantana. *L. decora* had no disease problems, was very damaging to lantana foliage and over-wintered in unheated glasshouses. A total of 115,000 *L. decora* were reared and released at over 100 sites in New South Wales. However, none of these field releases succeeded. This is almost certainly due to a high predation rate, particularly by spiders, combined with a long non-reproductive period over the cooler months. No release site population was ever observed to over-winter in New South Wales, although some very minor establishment has been reported in Queensland (Willson 1979b). Two biotypes were reared, the Peruvian from 1970 and the Columbian from 1972 (Harley 1973). These biotypes showed no obvious differences in appearance or behaviour.

The very small leaf-mining fly, *Calycomyza lantanae* (Frick) (Agromyzidae), was collected from Peru in 1969 by the CSIRO expedition and forwarded to Hawaii for host testing. The tests indicated that it was host specific. In 1973 supplies of this species were collected in Trinidad and forwarded to CSIRO Laboratories in Brisbane for further study (Harley and Kassulke 1974a).

Supplies of *C. lantanae* became available for release in New South Wales in 1974. A total of 2100 were released in the Sydney region, apart from releases in north-eastern areas of the State by CSIRO. Attempts to rear this species at Cumberland National Forest were not successful and possibly the Sydney area may be climatically unsuitable. Willson (1979a) reported *C. lantanae* to be well established only in North Queensland and that apparently it is incapable of surviving subtropical winters. Since then, however, some climatic adaption may have occurred because in 1981 this leaf-mining fly was found to be present in the Murwillumbah and Macksville areas of New South Wales. As yet this insect has not been sighted any further south. The full potential of *C. lantanae* is still some years away.

Second Joint Venture Introductions 1973 - 1976

With the success of the leaf mining beetles *Octotoma scabripennis* and *Uroplata girardi* further funding was provided to CSIRO and the Queensland Department of Lands to mount separate expeditions to South America in the hope of finding other lantana insects suited to Australian conditions, particularly warm temperate regions and shaded habitats.

The first three new species received in New South Wales from the latest expeditions were *Octotoma championi* Baly in September 1975, *Uroplata* sp. near *bilineata* in January 1976, (Diatloff 1977) and *Autoplusia illustrata* (Guen.) in November 1976. These comprised two-leaf mining hispine beetles and a noctuid moth. All were supplied by the Queensland Department of Lands and had originated from the Costa Rica-Colombia-Venezuela region of South America.

All three species were reared successfully in large exterior cages at Cumberland National Forest. The most promising is *O. championi* because of its much longer reproductive period than any lantana hispine beetle assessed so far, with egg laying continuing into early winter. Some 60,000 of these beetles have already been released into most areas of the State with the greatest effort being put into the Sydney region. *O. championi* has become established in the north-eastern coastal area of Sydney where it was first recorded as established in 1983, in the Avalon area. Since then it has established itself at Balgowlah, Narrabeen, Bilgola Beach and Whale Beach. *O. championi* shows a preference for shaded conditions, an advantage in forest areas, and it will readily infest the "Common Pink" lantana. The colonizing ability and potential range this beetle remains to be seen.

The second hispine beetle *Uroplata* sp. near *bilineata* was reared for 6 years from 1976 to 1981. However, its active period in the Sydney area is very short and so it is very slow to rear. Accordingly, only 3000 beetles have been released in New South Wales and no evidence of establishment has been seen. This species does not appear to be selective to any particular lantana taxon and was reared almost entirely on "Common Pink" lantana.

The last of the 1976 introductions was *A. illustrata*. This noctuid leaf-eating moth was reared for a period of 3 years. It is an easy insect to rear on "Common Pink" lantana in cages, with a short life cycle, although rather intensive in terms of labour required. Some 418,000 larvae were distributed throughout most of the lantana infested areas of New South Wales. Evidence of establishment either here or in Queensland has still to be seen. It is likely that, as with previous attempts using lepidopterous leaf eaters, native predators and parasites would have prevented any effective establishment.

The most recent lantana insects received were a southern biotype of *Uroplata girardi* Pic., *U. lantanae* Buzzi and Winder, and a halticid leaf beetle *Alagoasa parana* Samuelson. All three were imported by CSIRO from the Brazil-Uraquay regions of South America and were introduced into N.S.W. in 1980-81.

The two hispine beetles have been successfully reared at Cumberland National Forest but both are reproductively active for less than half the year making it difficult to produce large numbers for release. The more promising of the two is the southern strain of *U. girardi* which has been reared on "Common Pink" lantana. This variety of *U. girardi* can be distinguished from the original, which was introduced in 1966, by a variation in colour marking on the elytra and pronotum.

First released in 1981, 5500 of the southern biotype *U. girardi* have now been distributed mainly in the Sydney region. While there is no record of establishment, they have been observed to over-winter at one Sydney site before finally disappearing. This insect is still being reared.

The second hispine beetle *U. lantanae* has been reared on "Common Pink-edged Red" lantana but it has been observed that they will readily complete their life cycle on "Common Pink" lantana if the leaves are in lush condition. An interesting variation in the life cycle of *U. lantanae* is that it disappears from the foliage in late April or early May and reappears in October. The winter is spent in leaf litter at the bottom of the cages and there is no evidence of any feeding activity in the entire 6-month period.

Since a first small release in 1981, it has

been possible to release only 1500 beetles mostly 1985 and 1986 in the Kurrajong area where a large infestation of "Common Pink-edged Red" lantana exists. Evidence of establishment of *U. lantanae* is lacking but with such small releases it would be premature to judge its potential. Rearing of this species is continuing on a small scale.

Attempts to rear the halticid beetle *A. parana* at Cumberland National Forest failed. The culture was begun in 1981 and reinforced with additional larvae in 1983 but it died out in 1985. During this time small numbers of these beetles did complete their life cycle but always in diminishing numbers. However, some 700 larvae reared by CSIRO in Queensland were released in the Sydney area and other releases were made in the Coffs Harbour area by CSIRO. There is still no evidence of establishment of this species in either region.

A. parana has only one generation each year with an active period of 6 months. In open cage conditions at Cumberland National Forest the adults, having overwintered in leaf litter, commenced foliage feeding in late October. The larvae first appeared on the foliage in December and developed into adults in March. All activity ceased by the end of April when surviving adults returned to the leaf litter for the winter. Adult and larval feeding activity caused severe localised defoliation to the "Common Pink" *L. camara* used as host plant material.

Winder, Sands and Kassulke (1988) indicate that *A. parana* prefers moist conditions such as prevail in coastal rain forest fringes. The paper also details life cycle studies and host plant testing results. The moist conditions requirement, vulnerable larval stage and long life cycle are a distinct disadvantage to establishment of *A. parana* in New South Wales.

Damage to Lantana by Native Insects

Moore (1972) listed 33 species of insects which he observed feeding on *L. camara* during a limited survey of the central coast area of New South Wales. Most of the listed insects are native species which are non-host specific. Only a few of these species occur on lantana in large numbers and seldom cause much damage to the foliage because of the short duration of the infestations. The most obvious of the native insects that can occur in large numbers is *Scolypopa australis* Walk. (Hemiptera: Ricaniidae). This sap-sucking bug is often present on lantana in the early summer period. Infested lantana frequently becomes blackened from sooty mould on the exuded honey dew but does not appear to sustain much foliage damage.

Discussion and Conclusions

Of the 23 different species of lantana insects introduced into Australia since 1914, only 15 have become established. In New South Wales only four are in sufficient numbers to have potential for suppression of the weed *L. camara*.

The leaf-mining beetles *O. scabripennis* and *U. girardi* are widely established in the north eastern area of New South Wales and are quite damaging to the foliage of *L. camara*. No assessment on the direct suppression of lantana by these insects has been carried out in New South Wales. However, it is likely that some localized suppression is taking place but this would be difficult to measure in the short term. These leaf miners were first introduced into Australia 20 years ago and it is probable that their full potential in New South Wales may not be realized for another 20 years. This is thought likely because some climatic adaption seems to be taking place.

The agromyzid fly, *O. lantanae*, is the most widespread and abundant of the lantana insects but because it infests only the fruit of *L. camara* and is a very small insect, it is seldom noticed. The seed of lantana is widely dispersed by birds which feed on the fruit. Because this fly renders much of the fruit unpalatable it certainly lowers the full potential for seed dispersal though having no effect on the established plants themselves. *O. lantanae*, was first introduced into Australia more than 70 years ago and hence has probably reached its full potential in eastern Australia.

The last of the abundantly established lantana insects is *T. scrupulosa*. This sap-sucking bug is more restricted in its New South Wales range because it is selective in its host preference. "Common Pink" lantana, which is the most widespread of the pest taxa, is not usually attacked by this insect. West of Kempsey, where large areas of "Common Pink-edged Red" lantana occur, *T. scrupulosa* is sporadically very damaging and it appears to prevent expansion of the areas already infested by this taxon. *T. scrupulosa* was introduced more than 50 years ago and it, too, has probably reached its full potential in eastern Australia.

Three species of lantana insects are at present being reared on a small scale at West Pennant Hills. Of these *O. championi* has become established in the Sydney region and shows most promise of establishing over a much wider area. This leaf miner was first introduced in 1975 but the first record of establishment was not made until 8 years later. It will obviously be some time before any final assessment can be made on the value of this insect. The southern biotype of *U. girardi*, and *U. lantanae* are not yet known to be established in New South Wales. These need to be given more opportunity as only relative low numbers have been reared and released in this State so far.

A final conclusion about the effect of biological control on *L. camara* in New South Wales would be premature. The most obviously successful types of lantana insects are the leaf mining beetles, which is almost certainly due to their resistance to native parasites and predators. Haseler (1980) indicates that the full potential of leaf mining beetles already introduced is still many years away. It is also likely that some areas of New South Wales, where lantana is a weed, will be climatically unsuited to the present range of lantana insects.

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