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Introduction of the Gall Fly *Rhopalomyia californica* from the U.S.A. into Australia for the Control of the Weed *Baccharis halimifolia*

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Abstract

Baccharis halimifolia (Compositae) is a woody shrub native to the eastern coast of North America and is a serious weed in cattle pastures in Eastern Australia. In an attempt to control *B. halimifolia*, the gall fly *Rhopalomyia californica* (Diptera: Cecidomyidae) was introduced from California where it was collected from *B. pilularis*. In 1982, releases were commenced and the gall fly has established at most sites. Although there has been some attack by native parasites and predators, this is lower than the rate of increase. It has spread more than 10 km in 18 months and has stopped *c.* 90% of seeding at a heavily infested release site. This is highly significant as the massive annual production of wind-borne seed is one of the principal reasons why this plant is a serious weed. At this stage, it appears that the gall fly will give significant control of the weed, but it is still too early to know the long term effects on the plants and the degree of control that will finally be achieved.

Introduction de la Mouche Gallicole *Rhopalomyia californica* des États-Unis en Australie pour la Lutte Biologique Contre la Plant Nuisible *Baccharis halimifolia*

Baccharis halimifolia (Composée) est un arbuste ligneux indigène de la côte est de l'Amérique du Nord qui est très nuisible dans les pâturages du bétail dans l'est de l'Australie. Pour essayer de lutter contre *B. halimifolia*, la mouche gallicole *Rhopalomyia californica* (Cecidomyidés) a été importée de Californie où elle a été recueillie sur *B. pilularis*. En 1982, les lâchers ont commencé et les mouches gallicoles se sont établies dans la plupart des sites. Les galles ont atteint les extrémités des jeunes plants en croissance et des plants matures, ce qui a détruit environ 90% des graines. Il s'agit d'un succès exceptionnel puisque la production annuelle massive de graines disséminées sous l'action du vent est l'une des principales raisons pour lesquelles cette plant est si nuisible. A l'heure actuelle, on croit que la mouche gallicole luttera efficacement contre cette plant nuisible, mais il est encore trop tôt pour évaluer son rendement final.

Introduction

Groundsel bush (*Baccharis halimifolia* L.; Compositae) was introduced into Australia from North America during the last century, probably as an ornamental in Brisbane gardens. By 1900 it was recorded as having escaped from cultivation and had begun to spread (Bailey 1900). It now occurs along the well-watered and productive sub-tropical lands east of the Great Dividing Range along a coastal strip *c.* 1000 km long by 100 km broad, centred on Brisbane (latitude $27\frac{1}{2}°$) (Fig. 1).

Groundsel bush invades cattle pastures and can quickly form dense woody thickets up to 7 m tall. It is not poisonous to cattle but although young tips are occasionally browsed, stock prefer other pasture. It is undesirable in pasture because it displaces useful fodder plants.

Groundsel bush is a problem for the community rather than just the individual farmer because it produces great numbers of small wind-borne seeds each autumn which can be blown kilometres away. A 2 m high plant may produce half a million seeds (McFadyen 1972). The failure of a landholder to control the weed will inflict a continuing cost on neighbours as they fight a never-ending battle to keep their properties free of groundsel bush from seed blown onto their land.

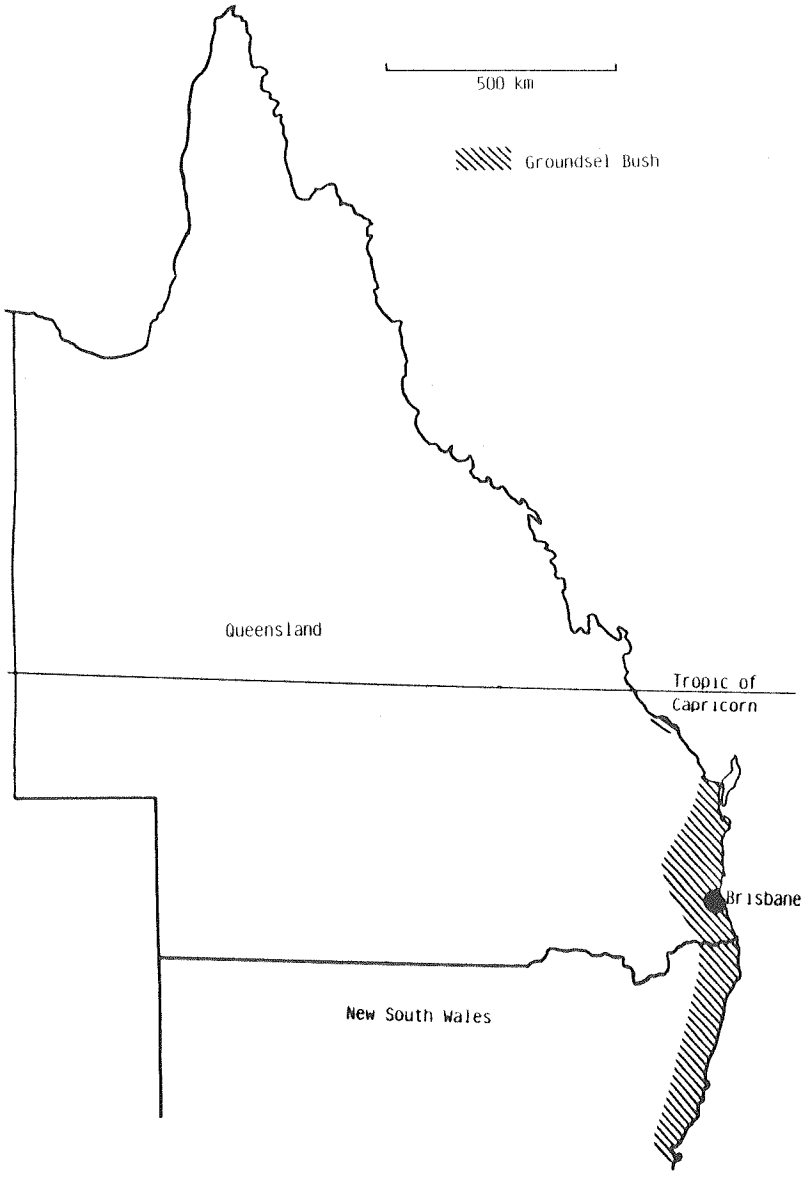

Fig. 1. Distribution of groundsel bush, *Baccharis halimifolia* L., in Australia.

In 1958, Dr. F.D. Bennett of the Commonwealth Institute of Biological Control was commissioned by the Queensland Department of Lands to undertake surveys of organisms attacking *Baccharis* species in North and South America. Between 1967 and 1980 host-specificity investigations were undertaken in Florida, U.S.A, and Parana,

Brazil, by Queensland Lands Department entomologists, and more than 20 species of insects were introduced (McFadyen 1979, 1981). One of these was the gall fly *Rhopalomyia californica* Felt (Diptera: Cecidomyiidae) which was tested for host specificity by Mr. G. Diatloff of the Queensland Department of Lands in Florida in 1968. In March 1969, in cooperation with Dr. R. Doutt, United States Department of Agriculture, San Francisco, it was introduced into Australia in quarantine, and in May 1969, a small release was made near Deception Bay north of Brisbane. The laboratory population declined rapidly and there were no recoveries following the field release.

In late 1969, further supplies were obtained from Dr. L.A. Andres, USDA, San Francisco, but these died out in quarantine. The lack of success in breeding and field establishment was not encouraging, particularly when compared with the success in the rearing and establishment of other species such as *Trirhabda baccharidis* (Weber) (Coleoptera: Chrysomelidae) and *Aristotelia* sp. (Lepidoptera: Gelechiidae) which were introduced from Florida about the same time and established quickly in Queensland. They were collected off *B. halimifolia* in Florida, an area climatically similar to southern Queensland, whilst *R. californica* was collected off *B. pilularis* DC. from the climatically different San Francisco area (Fig. 2) (Walter and Leith 1960). The failure of the *R. californica* introductions with the possibility of its unsuitability for *B. halimifolia* and Queensland climatic conditions put it low on the priority list for further work. Nevertheless, in June 1982 a further introduction was made from San Francisco, this time into new and much improved heated and humidified quarantine buildings. This time the population increased rapidly and by September 1982 the first releases were made near Brisbane and breeding colonies established in the field by the end of that year.

Development of *R. californica* on Groundsel Bush in Australia

R. californica adults are small, delicate flies *c.* 2 mm in length. After they emerge from the gall they mate and lay bunches of red eggs on young growing tips or in leaf axils. The adults rarely live more than a day. The larvae burrow into the tip and a gall, commonly 1 cm but up to 3 cm across, develops within 1 to 2 months (Fig. 3). After the flies emerge from the galls, the gall dies and there is stem dieback usually of 2 cm but up to 10 cm.

In the U.S.A. the biology and autoecology of *R. californica* on *B. pilularis* has been studied in some detail (e.g. Tilden 1951*a*, *b*; Doutt 1961; Force 1974; Ehler 1979, 1982*a*, *b*). In Australia, its biology and autoecology are generally similar except that the rates of parasitism are lower. Parasitism studies, 18 months after release in Queensland, show rates of parasitism of $< 10\%$ (McFadyen, unpubl. data) compared to rates up to 100% in California (Force 1974).

Spread of the gall fly in Australia probably largely depends on it being carried on the prevailing winds. Following a release, galls are commonly found in a 20 m radius around the release point in the first field generation (i.e. *c.* 1 month). However, within 18 months of release at one site, they have been recorded 10 km from the nearest release point and are still spreading.

Most releases have resulted in establishment. Some failures have occurred in late summer at the height of the 1982–83 drought when groundsel bush was drought stressed and not actively growing. Establishment has occurred in a variety of environments; in sun and shade, in coastal, inland and upland regions. In some areas increase has been more rapid than others, but no clear pattern is yet evident. Groundsel bush plants of all sizes are galled from 1 cm high seedlings to the tops of 7 m high bushes.

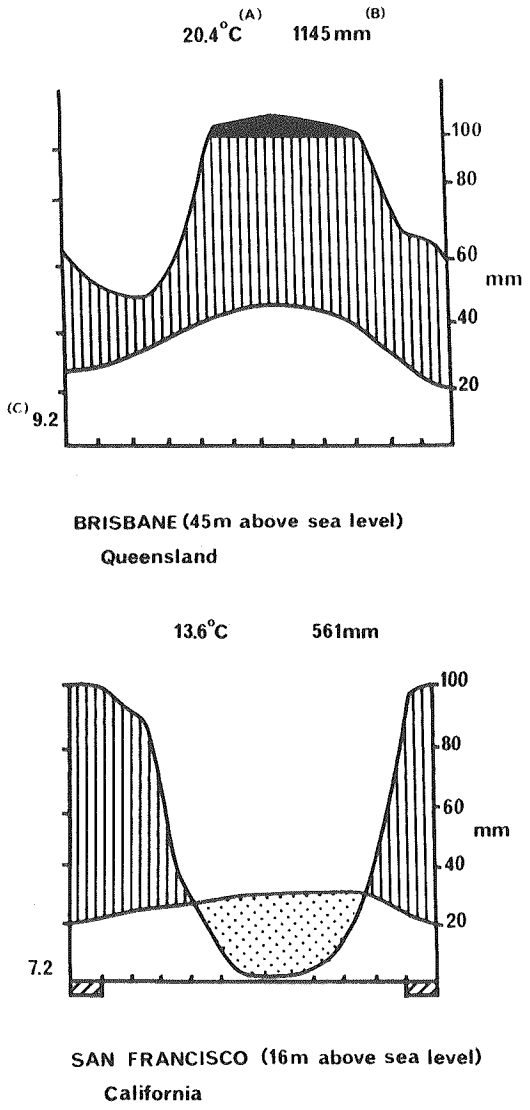

Fig. 2. Climate diagrams (Walter and Leith 1960) of Brisbane and San Francisco: (a) mean annual temperature; (b) mean annual precipitation; (c) mean daily minimum temperature of the coldest month.

Field Assessment of the Effect of R. californica *on Groundsel Bush*

The effect of heavy galling on flowering and seeding was assessed by comparing a heavily galled release site with similar sites nearby where galling was still low. The comparisons were made by aerial photography and by sampling plants. The area chosen for these comparisons was about 50 km south of Brisbane in the catchment area of the Hinze Dam (*c.* 20°S latitude). It is an area of wooded hills interlaced with ravines from which water intermittently flows into the Nerang River and then to the Hinze Dam. The river flats and some of the hillsides had been originally cleared for grazing and agriculture and are now densely covered with groundsel bush. On 12 November 1982, a release of eight pot plants of groundsel bush infested with galls of *R. californica* was made amongst a pure stand of 5 m high groundsel bush on alluvial river flats (Whipbird site).

Aerial Photographs

The purpose of the aerial photographs was to show the lack of flowers in galled areas and the abundance of flowers in ungalled areas. On 27 April 1984, aerial photographs were taken after flowering (when female plants are a dense mass of white and thus easy to see). The white appearance of the female plant is due to the expansion of the white parachute-like pappus attached to the seed. For a period of about 2 wks, the plants are a showy spectacular sight.

Fig. 4 is an aerial photograph of the general area taken at *c.* 1500 m. The reduction in flowering can be seen as marked. Figs. 5 and 6 are sections of the same area taken at *c.* 300 m. Fig. 5 is the heavily galled release area (Whipbird site) of *c.* 1 ha showing very little seed. Fig. 6 is a relatively lightly galled area and the white female plants are clearly evident.

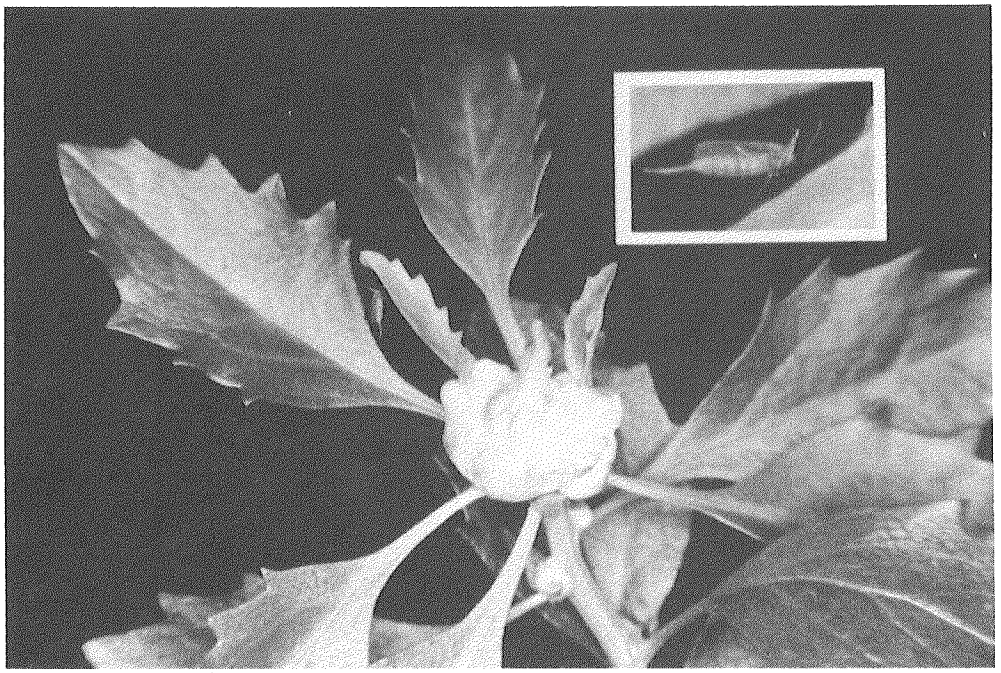

Fig. 3. *Rhopalomyia californica* Felt gall on groundsel bush, *Baccharis halimifolia* L. Inset: female *R. californica*.

Sampling Trials

Two sites were chosen 3 km apart. Both were on flat land fronting the Nerang River pondage of the Hinze Dam. In both areas, the groundsel bush was a pure stand *c.* 5 m tall. At the release site (Whipbird site), plants were heavily galled; at the control site (Boat site), only the occasional plant had a gall. One tip gall on a 5 m high bush with hundreds of ungalled tips was considered negligible damage by the gall fly, so the Boat site was regarded as being unaffected by the gall fly.

The sampling method at the Whipbird and Boat infestations was to select randomly 30 quadrats of 0.25 m^2 (0.5 $\times$ 0.5 m) and place four poles at each corner of the quadrat. This formed a column up through the groundsel bush. All flower buds falling within

this column were collected and counted. All quadrats were under full groundsel bush canopy.

The results presented in Table 1 show a very considerable average reduction of 93% in the number of capitula produced. It is clear from both the ground sampling and the aerial photography that the gall fly has caused a major reduction in seeding.

Fig. 4. (A) points to the release area of heavily galled, 5 m high groundsel bush, *Baccharis halimifolia* L. (B) points to white flowering female groundsel bush plants unaffected by gall fly, *Rhopalomyia californica* Felt.

Discussion

As *R. californica* was released less than 2 yrs ago, it is too early to know if it will be equally effective in all areas or whether some factor such as a sudden increase in parasitism may render it ineffective. However, it continues to increase and spread and as each month goes by, the confidence in its usefulness increases. Providing this increase and spread continues, it will cause a considerable reduction in the amount of seed produced.

As most seed falls quite close to the parent plant (Diatloff 1964), intraspecific competition among seedlings is important here, but not for seedlings from seed blown to clean or sparsely infested areas. In the latter case, any reduction in the total amount

of seed produced will mean a reduction in the spread of the weed as there will be fewer seedlings infesting clean areas. Additionally, attack by the gall fly on seedlings could be expected to slow seedling growth and increase seedling mortality rates, thereby further reducing the rate of spread. In the long term, the gall fly may kill mature plants by depleting their food reserves, but this remains to be seen. No clear evidence of plant death due to galling has been seen in the field so far, other than a few seedlings where galling is likely to have been a contributing factor.

Fig. 5. *Rhopalomyia californica* Felt release site (Whipbird site) with heavy gall fly attack. Few plants are flowering.

Apart from the practical advantages of the control of groundsel bush, the success of the gall fly in Australia illustrates some of the difficultues of prediction in biological control. It seems reasonable to assume that an insect from a similar climate and from the same plant species will be a more successful biocontrol agent than one from a different climate and from another plant species, albeit closely related. In the biocontrol programme against groundsel bush, insects which appeared the most logical choice were tried without success, whilst an insect which appeared to have only an outside chance in comparison so far appears to be successful. The difficulties of accurate and reliable prediction are obviously considerable.

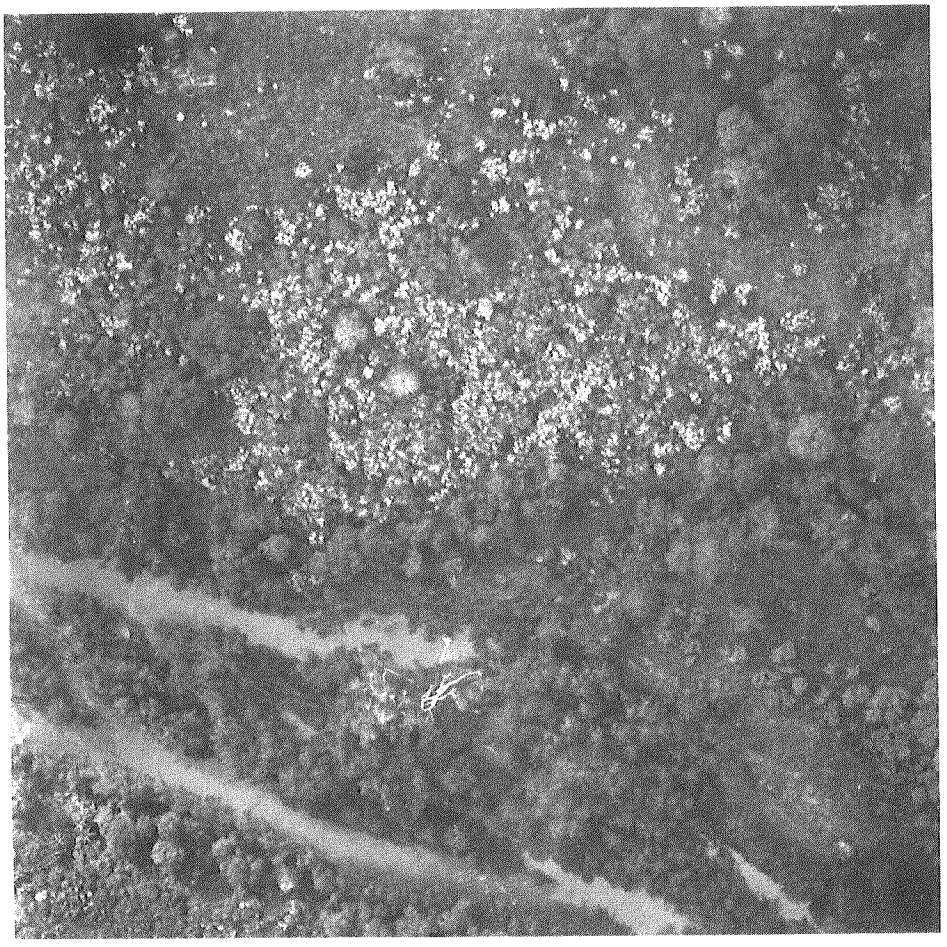

Fig. 6. An area only lightly attacked by *Rhopalomyia californica* Felt. Many white flowering female groundsel bush (*Baccharis halimifolia* L.) plants are evident.

Table 1. Effect of the gall fly *Rhopalomyia californica* Felt on seeding by groundsel bush (*Baccharis halimifolia* L.)

Site	Mean no. of flower heads per sample	Range	Percent reduction in seeding
Whipbird site (galled plants)	220	0-1,401	93%
Boat site (ungalled plants)	3,114	446-11,225	0%

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References

Bailey, F. 1900. The Queensland Flora. Part 3. A.J. Diddams & Co., Brisbane, Australia.

Diatloff, G. 1964. How far does Groundsel seed travel. *Qld. Agric. J.* **90(6)**: 354–6.

Doutt, R.L. 1961. The dimensions of endemism. *Ann. Ent. Soc. Amer.* **54**: 46–53.

Ehler, L.E. 1979. Utility of facultative secondary parasites in biological control. *Envir. Ent.* **8(5)**: 829–32.

_____. 1982*a*. Ecology of *Rhopalomyia californica* Felt. Diptera, Cecidomyidae, and its parasites in an urban environment. *Hilgardia* **50(1)**: 32 p.

_____. 1982*b*. Foreign exploration in California. *Envir. Ent.* **11**: 3.

Force, D.C. 1974. Ecology of insect host-parasitoid communities. *Science* **184**: 624–32.

McFadyen, P.J. 1972. Biological Control of Groundsel Bush (*Baccharis halimifolia*). M.Sc. thesis, University of Queensland, Australia.

_____. 1979. South American insects introduced into Australia for the biological control of *Baccharis halimifolia* L. Ph.D. thesis, University of Queensland, Australia.

_____. 1981. Current status of the biological control programme against Groundsel bush (*Baccharis halimifolia*). Proc. VI Aust. Weeds Conf., pp. 151–4.

Tilden, J.W. 1951*a*. The insect associates of *Baccharis pilularis* De Candolle. *Microentomology* **16**: 149–88.

_____. 1951*b*. Observations on *Rhopalomyia californica* Felt. *Pan-Pac. Ent.* **27**: 20–2.

Walter, H., and Leith, H. 1960. Klimadiagram Weltatlas. VED Gustav Fischer Verlag, Jena.