AN OVERVIEW OF THE RED IMPORTED FIRE ANT (*SOLENOPSIS INVICTA* BUREN) ERADICATION PLAN FOR AUSTRALIA

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On 22 February 2001, an Australian National Insect Collection taxonomist positively identified ant specimens submitted by two members of the public in Brisbane Australia as *Solenopsis invicta* Buren (red imported fire ants). Widely regarded as a serious agricultural and environmental pest as well as a threat to human health, its discovery triggered an emergency response by the Queensland Department of Primary Industries. Subsequent intensive surveillance revealed two separate and well-established fire ant populations covering approximately 36 000 ha of parkland, suburban areas and industrial land. A plan to eradicate this invasive species has been developed with funding of more than AU$120 million over five years granted by the Agriculture and Resource Management Council of Australia and New Zealand. Costs are shared between the Federal Government and the States/ Territories. The eradication program is possibly the most ambitious and important effort ever undertaken to eradicate an invertebrate pest in Australia. We present preliminary data on progress of the eradication effort to date and outline the relevant scientific studies conducted by various researchers in Australia.

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Red imported fire ants are an aggressive social insect with an original distribution centred on Brazil, Uruguay, Paraguay and northern Argentina (Lofgren et al. 1975; Vinson & Sorensen 1986; Taber 2000). In its homeland it not a particularly abundant organism (Porter et al. 1997), but elsewhere in the world where it has become established such as in south-eastern USA (Thompson et al. 1998), California (Klotz et al. 2002), Puerto Rico (Callcott & Collins 1996) many islands in the West Indies (Davis et al. 2001) and now Australia (Nattrass & Vanderwoude 2001), it quickly expands its range (Lofgren et al. 1975; Callcott & Collins 1996) and dominates the landscape (Porter et al. 1997) to the detriment of native ant species, other invertebrates and humans. One of its greatest adaptive strengths is an ability to survive even in ruderal and disturbed habitats (Tschinkel 1986).

Tchinkel (1986) considers fire ants to be the perfect 'weed' species. Features that stand Red imported fire ants in good stead in this regard include: polygyny coupled with high inter-specific aggression, aggressive colony defence and a painful sting resulting at times in cases of anaphylaxis (Caro et al. 1957; Rhoades et al. 1977; Adams & Lofgren 1981; Blum 1982; deShazo et al. 1984; Stablein et al. 1985; Candiotti & Lamas 1993) and death (Stablein et al. 1985; Yunginger et al. 1991); an ability to rapidly relocate the colony should conditions become unfavourable (or should better habitat be found elsewhere) and competitive dominance at food resources. *Solenopsis invicta* has well-defined colonies with a distinctive internal gallery structure (Vinson & Sorensen 1986) that resembles termite colonies. Normally they form a distinctive domed mound which can be as much as 45 cm above normal ground level, but is often much smaller (Oi et al. 1994).

History of invasion

In the 1930s, *S. invicta* was discovered in the southern USA near Mobile, Alabama where it probably arrived with soil ballast from ships that traded between South America and Mobile (Vinson & Sorensen 1986; Taber 2000). It was not until twenty years later however, that it was recognised as a serious pest and a large-scale attempt at eradication was made with funding by the United

States Congress in 1957 (Vinson & Sorensen 1986). This eradication program featured widespread aerial baiting with heptachlor and then mirex as the active ingredients (Vinson & Sorensen 1986) and ceased in the 1960s when the registration for mirex was withdrawn (Williams et al. 2001). Today, *S. invicta* occupies much of southern USA (Callcott & Collins 1996) and estimates of the cost to the USA economy approach AUS$2 billion dollars annually (Wright et al. 1999).

Understandably, the discovery of *S. invicta* in Brisbane in February 2001 caused an immediate emergency response by the Queensland Department of Primary Industries. Widespread surveillance activities identified two well-established infestations in Brisbane covering over 36 000 ha (Fig. 1). Tracing the previous movement of high risk items from infested commercial premises resulted in the discovery of a small infestation near Cooroy, some 150 km north of Brisbane, and a consignment of infested plants in Victoria. The mode of entry or the length of time that *S. invicta* has been in Australia are both unclear, however, it most probably arrived with sea cargo and remained undetected for more than five years.

The eradication plan

A scoping study commenced in March 2001 and was completed in June 2001. The aims of the study were to: determine the extent of the infestation; to evaluate the feasibility of eradicating *S. invicta*; and to assess the effectiveness of various available treatment options. This study was funded through national cost-sharing arrangements for incursions of agricultural pests and diseases.

Extensive surveillance for red imported fire ants was carried out in Brisbane during this period. Over 9000 properties were inspected for the ant in these first three months alone. Almost 4000 inspections were as a result of requests by the public due largely to intense media interest.

The scoping study led to a plan to eradicate red imported fire ants and was developed by an advisory panel of myrmecologists and pest incursion specialists in collaboration with operational managers and a team of specialists from the United States of America (S. D. Porter, C. L. Barr & B. M. Drees).

FIGURE 1. Area of Brisbane (shaded) putatively infested by *Solenopsis invicta.*

The Agriculture and Resource Management Council of Australia and New Zealand (now Natural Resources Standing Committee) endorsed and funded a national plan to eradicate *S. invicta* from Australia by June 2006. This plan consists of several key elements:

1. Repeated treatment of infested and putatively infested areas with baits containing the insect growth regulators s-methoprene or pyriproxyfen;
2. Careful surveillance of surrounding areas and high risk areas throughout Australia to ensure all outlying colonies are identified and treated, including monitoring for two years beyond the cessation of treatment to ensure eradication has been successful;
3. Establishment of rigorous controls over the movement of substances likely to harbour *S. invicta* (plants, soil, sand, turf, hay, etc.);
4. A strong public awareness and community engagement strategy; and
5. A research group providing the following services to the program: a) ecological and environmental research; b) diagnostics support; c) post-treatment validation; and d) development of control and disinfestation methods.

This program commenced in September 2001 and involves over 500 full-time staff in the initial eradication phase. Most of these are field assistants engaged in treatment or active surveillance activities.

Research Activities

The Fire Ant Control Centre research program promotes collaborative projects which has resulted in the development of ten postgraduate studies at seven universities (Table 1). These studies are important components of the overall research plan and have been integrated with the research project areas described below.

Ecological and environmental research

The ecological research program has three main objectives:

1. To study those aspects of the biology of the imported red fire ant, which assist with treatment, risk management, surveillance, and community awareness;
2. To study the impact of fire ant eradication program on non-target fauna; and
3. To provide ecological input into any post-treatment rehabilitation of native fauna.

Colony growth, survival rate of small colonies and knowledge about the time to reach key life-stage events such as production of reproductives are all important aspects of fire ant biology that are not well studied. Research elsewhere shows that polygyne colonies spread by budding (Porter et al. 1988; Vargo & Porter 1989). Queens leave their maternal nests and found a colony nearby. A

TABLE 1. Postgraduate projects supporting the *Solenopsis invicta* eradication program

Student	Supervisor	Institution	Project
Tania Fuessel	Clyde Wild	Griffith, Gold Coast	Impacts of treatment on soil invertebrates
Chris Gough	Carla Catterall	Griffith, Nathan	Impacts of treatment on native ant communities
Rowena Warne	Ian Williamson	Queensland University of Technology	Impacts of treatment on scincid lizards
Nicole Kunzmann	Ross Crozier	James Cook University	Population genetics
Jemma Somerville	Jane Hughes	Griffith, Nathan	Population genetics
Samantha Bonney	Clyde Wild	Griffith, Gold Coast	Population morphometrics
Kay Montgomery	Clyde Wild	Griffith, Gold Coast	Life cycle and colony growth
Robert George	Hamish McCallum	University of Queensland	Habitat modelling
Heike van Gils	Joop van Lenteren	University of Wageningen	Urban ant communities
Melinda McNaught	Lisa Lobry de Bruyn	University of New England	Invasion biology

founding queen (or queens) takes workers or adopts some on route. Queens work together to excavate a chamber where all the queens lay eggs and care for the brood (Vargo 1988). Studies of laboratory cultures aim to answer some of these basic questions.

The impact of fire ant infestations on soil and litter fauna, including mobile ground fauna (in particular native ants) is being assessed through a number of studies that compare soil and litter invertebrate fauna in infested and uninfested sites through pitfall trapping, soil and litter extractions and observations of the interactions of foraging fire ants and native ants.

Solenopsis invicta generally nest in the soil and forage in and on the soil as well as on plants, although extensive arboreal foraging has not been observed. They utilize a wide range of food types, eg fungi, bacteria, plants, soil and litter fauna and honeydew (Taber 2000). The baits used in this eradication program could impact on a range of non-target invertebrates. The active ingredients in the baits are common to a range of pest control products, and therefore some impacts on non-target organisms may be expected in such a large-scale treatment program. Both the fire ants and the baits therefore potentially impact on soil, litter and the larger mobile ground fauna. A component of this fauna, along with fungi and bacteria, play an important role in decomposing organic matter and cycling plant nutrients through the ecosystem. Changes in faunal composition may cause changes in decomposition processes as fauna are implicated in the movement of and inoculation by bacteria and fungi spores as decomposition takes place. In addition, these fauna provide food for a range of terrestrial invertebrates (eg spiders, centipedes) and vertebrates (frogs, reptiles, birds and mammals). Comparative studies involving a range of fauna (soil and litter fauna, native ants, frogs and skinks) of treated and untreated sites are underway. The response of a range of native ant genera to bait types is being studied in the field. Bait types include a range of active agents (hydramethylnon, pyriproxyfen, s-methoprene), substrates (corn grit, wheat based) and bait sizes.

Diagnostics

The diagnostics unit provides taxonomic support to both the surveillance effort and the other research programs. Since 22 February 2001 staff of

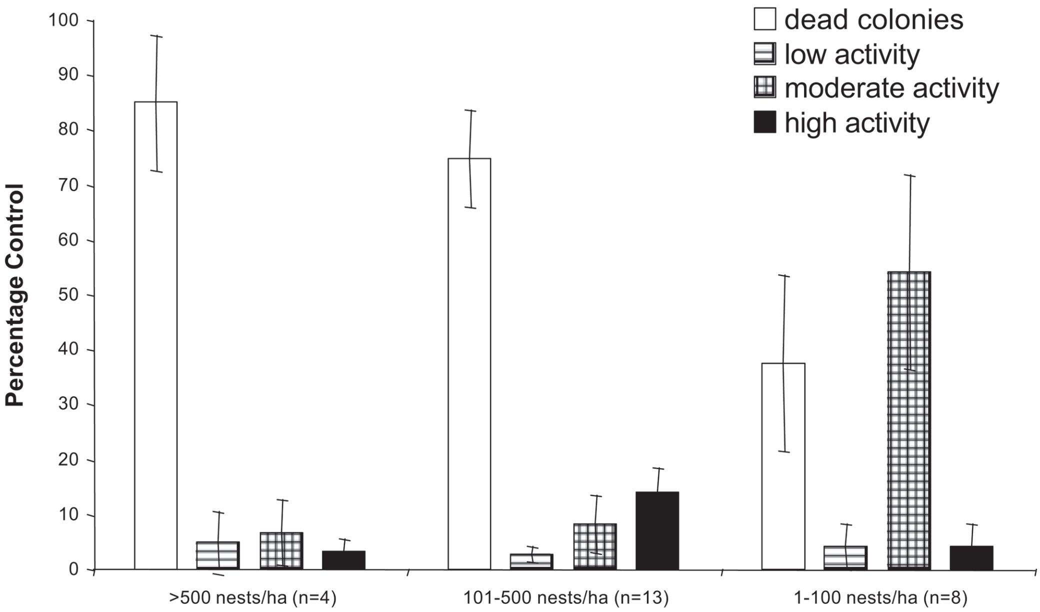

FIGURE 2. Level of control of *Solenopsis invicta* achieved in monitoring plots of various densities based on assessments of nest activity after two treatments (error bars represent standard errors of the means).

the diagnostic unit have processed in excess of 19 000 samples with 1754 confirmed positive for *S. invicta*. Samples are received from the structured surveillance operation as well as concerned members of the community. Each sample is assigned a unique number linking the sample with the appropriate submission forms containing relevant information, eg ownership, date, locality and identification (ants in all negative samples are identified to genus). This information is then added to a central database.

To date, ants from 48 genera have been identified in urban Brisbane and voucher specimens have been added to the central ant collection housed at the Fire Ant Control Centre. Some of the more unusual or rarely collected genera in urban areas are *Anisopheidole, Glamyromyrmex* and *Machomyrma,* while the most common genera submitted are *Camponotus, Iridomyrmex, Pheidole, Rhytidoponera* and *Tetramorium.*

Post-treatment validation

The monitoring program is responsible for measuring the effect of the treatment program on the *S. invicta* population and to document their decline. To date approximately 60 sites have been established and maintained to monitor *S. invicta* populations within the current treatment zones. The addition of new sites will continue as the infestation situation dictates. A system of pitfall traps is strategically placed throughout selected plot areas on infested properties. The plots were located to cover high, medium and low-density infestations on a variety of land use types including rural, semirural, industrial and residential situations. Where possible the sites were established prior to the initial treatment to gain baseline population data by which to measure the effectiveness of the treatment regime.

Data collection for the monitoring program includes setting, collection and sorting of 1400 pitfall traps per month. All ants are sorted to genus and resulting datasets contribute to the ecological research on native ant distribution and effects of treatment on other invertebrate species. As well as assessing ant activity through pitfall traps, the monitoring team collects information on the activity and density of nests within plots. Mid-summer assessments of nest density counts (Fig. 2) and pitfall trap data both indicate that approximately 80% of nests have already been eliminated.

Development of control and disinfestation methods

Preventing the spread of *S. invicta* beyond its current distribution is a vital part of the eradication plan. *Solenopsis invicta* is readily translocated by the movement of infested material such as soil, turf, pot plants and hay. Therefore, suitable disinfestation methods are needed in order that such material may move from the currently infested area. Research into the use of the fumigant methyl bromide to disinfest *S. invicta* in baled hay showed the usage rate of 32 g/m^3 to be efficacious and allowed registration for this use. The use of steam to heat soil sufficiently to kill *S. invicta* is also being tested. A small scale trial using steam jets inserted into a box trailer full of soil has been very successful. Larger scale work involving a commercial plant is currently under way. Trial work with emulsifiable concentrate formulations of chlorpyrifos have given experimental support to the practice of dipping or drenching potted nursery stock. However, the slow release formulations of chlorpyrifos (eg SusCon Green®) are expected to integrate more readily into the agronomics of nursery production and possibly afford a longer period of protection. A trial of this protection period is currently underway and shows promising results.

The performance of new actives such as fipronil and spinosad are being compared with the baits currently being used such as, hydramethylnon, pyriproxyfen and methoprene.

Conclusions

Results to date are promising and there is a good probability that *S. invicta* can be eradicated. Should *S. invicta* continue to spread, the potential ecological impacts are unimaginable. This incursion demonstrates how easily a major insect pest can enter Australia and remain undetected even in a highly populated area such as Brisbane, and indicates the need for continued and greater allocation of resources to national quarantine and monitoring efforts.

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