# Red Imported Fire Ants: A threat to eastern Australia's wildlife?

**By Shane Moloney and Cas Vanderwoude**

***The discovery of the Red Imported Fire Ants* (Solenopsis invicta) *in Brisbane on 22 February 2001 sent shock waves through urban and rural communities alike. This article is an attempt to address the often repeated question 'What will become of Australia's unique fauna if they spread along Australia's eastern seaboard?***

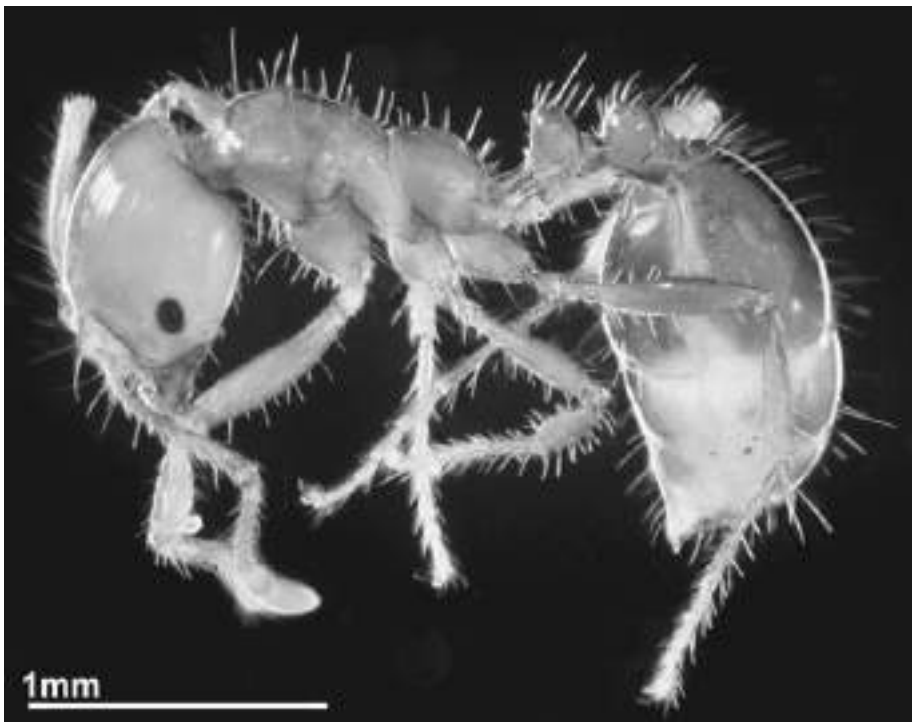


**Figure 1.** Red Imported Fire Ant worker. This species is greatly polymorphic and workers may be anywhere between 2 and 6 mm in length. (Photo courtesy of Macquarie University.)

*This review was prepared by **Shane Moloney** and **Cas Vanderwoude** as part of their work with the Queensland Department of Primary Industries Fire Ant Control Centre (PO Box 1241 Oxley, 4075 Qld, Australia. Email: shane.moloney@dpi.qld.gov.au). Its purpose is to collate information on the species to better support the current efforts to control this newly introduced pest species.*

## Introduction

The invasive Red Imported Fire Ant (*Solenopsis invicta* Buren) (Fig. 1) was detected in Brisbane, Australia early in 2001. This species is an important economic and ecological pest in North America, where it has been present since its accidental introduction from its native range in South America around 70 years ago (Vinson & Greenberg 1986; Callcott & Collins 1996; Vinson 1997). Since that time, the species has spread across the southern states of the USA, wreaking havoc on agricultural crops (Drees *et al*. 1998), animal production and farm infrastructure, especially electrical equipment (MacKay & Vinson 1990; Vinson & MacKay 1990; MacKay *et al*. 1992). In urban areas, the ants threaten human health through their painful stings, which may induce life-threatening allergic reactions. Symptoms include flushed skin, hives, swelling of the face, eyes or throat, difficulty breathing or loss of consciousness and, in severe cases, death (Lockey 1980; Bloom & DelMastro 1984; Stablein *et al*. 1985; Rhoades *et al*. 1989; Solley *et al*. 2002).

It is relatively easy to make assumptions about the likely effects of this pest in

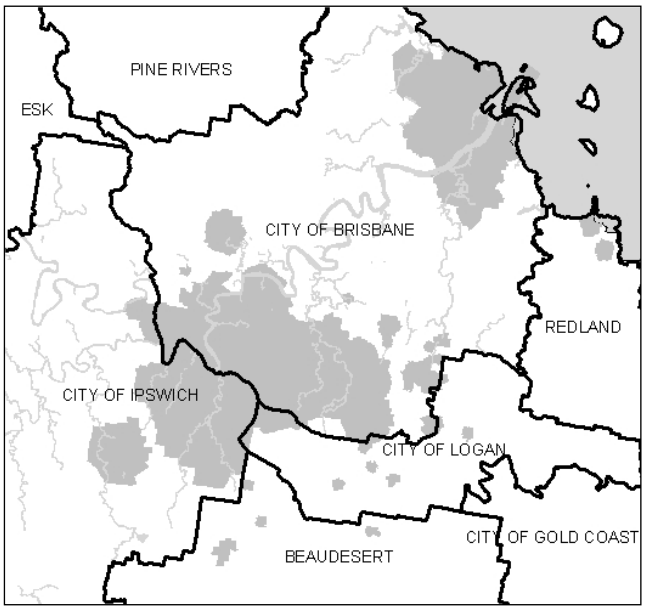


**Figure 2.** Map showing areas infested by the Red Imported Fire Ant (grey regions) currently undergoing treatment by the Fire Ant Control Centre within the Greater Brisbane region, Queensland, Australia. (Photos courtesy of Queensland Department of Primary Industries.)

urban and agricultural situations in Australia by extrapolating from the USA experience. Indeed, this extrapolation was a major driving force in the decision to fund an eradication effort by the Commonwealth government and all Australian states. However, the likely impacts on Australian ecosystems are more difficult to estimate as the animals and plants that make up our ecosystems are often different from those in the USA.

The effects that Red Imported Fire Ants had on a single forest remnant in Australia have been described elsewhere (Nattrass & Vanderwoude 2001). However, what will become of Australia's unique fauna should Red Imported Fire Ants spread along Australia's eastern seaboard? Introductions of exotic pests are recognized as a major threatening process leading to biodiversity loss (Pell & Tidemann 1997; Mack & D'Antonio 1998; Dick & Platvoet 2000; Hall & Mills 2000), and fire ants are recognized as one of the most serious social insect pests worldwide. A total of five ant species have made it onto the IUCN 'Top 100' list of the world's worst invasive species and, without doubt, Red Imported Fire Ants are the worst ant species on this list. There are some obvious difficulties associated with extrapolating ecological effects of Red Imported Fire Ants on the Australian fauna, not the least of which are the large differences between southern USA and Australia's eastern seaboard. In this review, we use available literature on the impacts of fire ants on fauna in the southern USA and our observations of Red Imported Fire Ants in the Brisbane area to estimate their impacts on fauna in Eastern Australia. Although this review will focus on potential impacts on species that have been listed as of conservation concern in Queensland or New South Wales (*Queensland Nature Conservation (Wildlife) Regulation 1994*, *New South Wales Threatened Species Conservation Act 1995 Schedule 1 & 2*), other species currently regarded as secure may be affected by Red Imported Fire Ants. An example of a previously common species impacted by an invasive organism is that of (*Litoria aurea*) the Green and Golden Bell Frog (Osborne 1990; Pyke 1999). It was originally an abundant and widespread species in its endemic area of south-eastern Australia, but it has disappeared from over 90% of its range and is now listed as endangered (Pyke 1999).

## Potential distribution of Red Imported Fire Ants in Australia

Red Imported Fire Ants are currently restricted to areas from the city of Brisbane, the bordering cities of Ipswich and Logan, and a small portion of Redlands Shire (Fig. 2). If they were allowed to spread throughout Australia unimpeded, where, and how quickly, would they colonize? Evidence from the USA suggests that Red Imported Fire Ants will occupy any land with mean annual rainfall exceeding 510 mm (Korzukhin *et al*. 2001), excepting areas that experience extremes of cold. Modelling of potential rates of spread (Scanlan 2001) indicates that at least 600 000 $km^2$ and as much as 4 000 000 $km^2$ will be infested by 2035.

Only general comments can be made about specific habitat preferences of Red Imported Fire Ants. Areas of closed forest are likely to be undesirable habitat for them as the degree of insolation and high soil temperatures needed for most ant species are not present. Personal observations of the location of colonies in the Brisbane area indicate an association with open and disturbed ecosystems including cleared or partially cleared areas, farm paddocks, parks, industrial sites, residential areas, open forests and sites adjacent to waterways. This may be the result of deliberate site selection by newly inseminated queens indicating a preference for open sites, or site-specific founding success due to factors such as biotic resistance. Biotic resistance simply refers to the fact that introduced species often fail to invade non-disturbed communities because the resources that they require are already used by existing organisms. In the case of Red Imported Fire Ants, established native ants may compete with young fire ant colonies for resources and/or kill Fire Ant queens (Porter *et al*. 1988), thus slowing their advance by reducing founding success. However, this is only the first wave of Red Imported Fire Ant invasion. The polygynous form, which dominates Brisbane's western suburbs, is able to spread through colony fission and budding to form interconnected super-colonies covering many hectares. The observations

by Nattrass and Vanderwoude (2001) are in an area where Red Imported Fire Ants have spread laterally into a forested area. Although this site shows signs of disturbance, such as weed invasion, this fragment is structurally similar to larger, intact fragments in the region, suggesting potential for this species to move beyond open sites of initial introduction to intact bushland. As such, their observations give us a glimpse of the future should eradication not succeed. It is our 'precautionary' speculation that closed forest ecosystems will not be greatly threatened by Red Imported Fire Ants, but most remaining areas including open forests will be suitable Red Imported Fire Ant habitat.

## Potential impacts on native species

### Ant communities

While no individual ant species are currently listed as being of conservation interest in eastern Australia, ants are an important part of ecosystems, and simplification of ant communities can lead to changes in biotic and abiotic variables (Holldobler & Wilson 1990; Folgarait 1998). These changes can have a 'knock on' affect that can alter the faunal and floral structure of an ecosystem (Jones *et al*. 1994). The loss of ant species from an area can also affect other species that rely substantially on native ants for food (Abensperg-Traun & Steven 1997), or to complete their life cycle (Eastwood & Fraser 1999).

The Red Imported Fire Ant has reduced the abundance and diversity of ants since its introduction to North America (Porter & Savignano 1990; Pennisi 2000). It has displaced native and introduced ant species in both disturbed and undisturbed habitats, as well as being implicated in the extinction of a number of native ant species (Porter *et al*. 1988; Camilo & Phillips 1990). Heavily infested native ant communities can have as little as 30% of their original species richness remaining, and the presence of the polygynous form of Red Imported Fire Ants has reduced the abundance of native ant species in some areas by up to 90% (Porter & Savignano 1990). In these highly infested areas, Red Imported Fire Ants can account for almost 99% of ant individuals collected (Porter & Savignano 1990; Gotelli & Arnett 2000). Initial observations of Red Imported Fire Ants in Australia suggest that this will also occur here. Such reductions in abundance of native ants must eventually result in species losses. The magnitude of these losses can only be guessed.

Native ants are unlikely to be displaced through direct predation because Red Imported Fire Ants rarely use other ants as a food source (although they will prey upon founding queens and queens taken during attacks on nests) (Porter & Savignano 1990; Vinson 1997). It is more likely that native ant populations will be less able to compete for resources (Porter & Savignano 1990; Stiles & Jones 2001). Competitive displacement takes two forms. Exploitative competition occurs when access to a shared resource is restricted by the actions of another species, while interference competition involves direct interactions of species resulting in a loss of fitness (Morrison 2000). Although interference competition is likely to be a factor during territorial disputes and resource defence, a major impact of Red Imported Fire Ants on native species is likely to be exploitative, particularly for polygyne colonies. Suppression of native ants through competition will be assisted by the high densities associated with established polygyne infestations (Holway & Suarez 1999) and the wide variations in worker size characteristic of this species that may enable them to use a broader feeding niche (Porter & Savignano 1990).

Native ant communities in Australia are more diverse and abundant when compared with North American ant communities, and this is likely to influence the rate of invasion by Red Imported Fire Ants. Personal observations reveal that Red Imported Fire Ants are meeting with substantial biotic resistance from native ants along invasion fronts. In open environments, Australian ant communities are dominated and controlled by Dominant Dolichoderinae (Andersen 1990). In drier areas, this group comprises largely of species from the genus *Iridomyrmex* but replaced by *Anonychomyrma* in wetter areas. In localized areas, species of *Froggattella* and *Papyrius* can be important. These ants are ubiquitous, numerous, fast-moving and aggressively dominate food resources. While site-specific habitat variables influence the abundance of Dominant Dolichoderines, they, in turn, regulate the abundance of other ant groups. Subordinate Camponotini such as species of Sugar Ants (*Camponotus*), Spiny Ants (*Polyrachis*) and Strobe Ants (*Opisthopsis*) are behaviourally subordinate to Dominant Dolichoderines but become dominant in their absence. The presence of these two groups, in turn, influences the abundance of disturbance-adapted Opportunists (such as species of *Rhytidoponera*) and species with unspecialized foraging strategies (e.g. species of *Pheidole*). Remaining ants avoid interaction with dominant species by foraging at different times (Cold, Hot or Tropical Climate Specialists), different locations (Cryptic Species) or for different resources (Specialist Predators).

Red Imported Fire Ants do not play by these rules. They monopolize all resources at virtually all times and locations, thus resulting in dramatic simplification of community structure. Observations of foraging behaviour by M. McNaught (unpubl. data, 2002) strongly indicate that once Red Imported Fire Ants locate a resource, they exclude all other ants from it.

### Other arthropods

The polygynous form of Red Imported Fire Ants has the potential to affect invertebrate communities largely due to their high densities. Populations of North American native ant species have been replaced by the introduced species at ratios of up to 6 : 1 (Morrison 2000) and this increase in ant densities is likely to divert resources from other invertebrate groups (Porter & Savignano 1990). The increased numbers of ants in an area are also likely to negatively affect native arthropods through increased predation. Red Imported Fire Ants prey upon a wide range of invertebrates and will predate all life stages including eggs larvae, pupae and adults (Stiles & Jones 2001). In infested areas, declines in arthropod species richness of up to 40% have been detected (Allen *et al.*

## Box 1: Management actions to date

**The** National Fire Ant Eradication Program is funded by contributions from all States & Territories and started during September 2001. Through a 5-year programme run by the Red Imported Fire Ant Control Centre, it aims to completely remove the Brisbane infestations by treating every property in the infested area (approximately 70 000 properties) four times each year during the first 3 years. Surveillance will then continue for a further 2 years to ensure that no areas become reinfested. The programme has a budget of $123 million and a workforce of around 500 staff during the initial phase of the programme. A scientific panel, comprising leading scientists from around Australia, oversees technical experts and an environmental advisory group provides input for environmental aspects of research. The programme is divided into the following key areas.

## 1. Treatment


**Figure 3.** Control of Red Imported Fire Ant is being undertaken using baits attractive to foraging Red Imported Fire Ant workers. Different application methods have been used to treat the variety of sites found within the treatment area, with small hand spreaders used in suburban areas, spreader-mounted Ag-Bikes treating open areas under 10 ha and helicopters used for open areas over 10 ha and areas of bushland.

The treatment programme is centred on the use of attractant baits that are taken back to the nest by Red Imported Fire Ant workers. These baits feature a carrier (corn grits), an attractant (soya oil) and an active ingredient (methoprene, pyriproxyfen or hydramethylnon). The first two active ingredients are insect growth regulators that do not kill the ants but prevent the queen from laying fertile eggs and stop the larvae from developing into mature ants. The lifespan for worker ants is often no more than a few weeks. When these are not replaced by newly emerging adult ants, the colony declines and is eventually eliminated. Hydramethylnon, the third bait type, is a slow-acting stomach poison that has been used extensively to treat Red Imported Fire Ant nests in North America. The slow-acting nature of this bait increases the likelihood of the toxin fully circulating throughout the nest, including to the queen, before the carrier ants die. Hydramethylnon is faster acting than insect growth regulators and is used to provide a quick reduction of Red Imported Fire Ant numbers in infested areas.

Only very small quantities of bait (1/2 teaspoon or 83 grains/$m^2$) are used. This works out at 200 g for a 1000 $m^2$ suburban block. The baits are applied using hand-held fertilizer spreaders in suburban areas, by larger fertilizer spreaders and Ag-Bikes on larger blocks; and by helicopter for areas of bush or farmland over 10 ha (Fig. 3). While the treatment programme has been designed in such a way as to minimize its impact on native fauna, a number of studies are currently underway to determine if any unforseen direct or indirect impacts have the potential to occur. These studies encompass both vertebrate and invertebrate groups, and the information acquired will allow decisions, such as the necessity of reintroducing species, to be made.

## 2. Surveillance

Surveillance is conducted to ensure Red Imported Fire Ants have not spread beyond the current boundary and to detect any new nests. Each property in a 3 km zone around known infested areas will be inspected annually for Red Imported Fire Ants. Beyond this area, partial surveillance will also be conducted with intensity decreasing with increasing distance from infested areas. At the completion of the treatment phase, surveillance will concentrate on ensuring all colonies in the treatment area have been found and destroyed. Ant samples collected by the surveillance teams are sent to the Diagnostic unit within the Fire Ant Control Centre where they are identified to genus and, if Red Imported Fire Ants are found, the details are immediately forwarded to appropriate sections for mapping and treatment. As of the end of April 2002, approximately 24 000 samples, some containing up to eight ant genera, have been processed and identified.

## 3. Movement controls

To prevent human-assisted movement of Red Imported Fire Ants into new areas, new regulations have been developed to control the movement of high-risk material (such as soil, mulch and hay) from inside the infested area to outside uninfested zones. These controls are part of *The Plant Protection Act 1989* and its associated regulations, as set out by the Queensland State government.

## 4. Education

An important component of the Red Imported Fire Ant eradication programme is ensuring that consistent and accurate information reaches industry and the general community. This is being achieved through a public relations and community engagement unit that organizes talks and displays at schools, clubs, shopping centres and public events and training days for industry groups and government workers. The unit also manages media releases and a passive surveillance programme that encourages members of the general public to send in samples of suspicious ants.

## 5. Research

Research and development projects have, to date, concentrated on alternative methods for controlling Red Imported Fire Ants and ways to treat infested produce such as hay, pot plants and items containing soil. Alternative treatment methods are also being tested. Ecological research includes a wide range of projects associated with the eradication programme. Examples include the effect of the treatment programme on non-target native ant species, other soil invertebrates, scincid lizards, frogs, as well as on foraging behaviour and invasion biology.The effect of the treatment programme on Brisbane's Red Imported Fire Ant population is being measured by a monitoring team. At present, 48 sites are being monitored using pitfall traps that are currently being set monthly. The locations of active nests are mapped for each study site with a proportion of these regularly examined to gauge the number of ants present.

## 6. Mapping and database

**Substantial amounts of data are being generated by treatment, surveillance and scientific activities. These are all collated, entered and validated on a single database (Fire Ant Information System). Data can be accessed in a variety of means including spatial and summary forms.**

## 7. Implications for the future

**While there can be no argument that the National Fire Ant Eradication Program will require a substantial amount of funding, the cost of not eradicating is enormous. An economic analysis by the Australian Bureau of Agriculture and Resource Economics concluded that the economic impact of Red Imported Fire Ants would exceed eight billion dollars over the next 30 years. Potential ecological impacts are difficult to value in dollar terms. We have attempted to identify which of Australia's already threatened species would be at further risk of extinction through the uncontrolled spread of Red Imported Fire Ants and the list is too long to contemplate the possibility that eradication will not be successful. Fortunately, experts both in Australia and overseas believe the eradication programme has a high probability of success. Furthermore, early results from monitoring data indicate that eradication milestones are being met.**

1995). Taxa negatively affected include beetles, ticks, spiders and flies (Hu & Frank 1996).

While the following paragraphs cite a number of known threatened invertebrate species, it must be noted that our knowledge of arthropods is poor in comparison with vertebrate fauna and it is likely that many other species not yet known to science are also at risk. Known species of conservation concern include a moth from NSW and two Queensland butterflies. The Golden Sun Moth (*Synemon plana*) has declined due to habitat loss, of which less than 0.5% of the original habitat remains and is currently only known from a small number of sites in Victoria, ACT and NSW (Dugteren 2001). As its preferred habitat is native grasslands, there is a high likelihood that this species would be adversely affected if Red Imported Fire Ants entered its range, and a high level of predation would be expected.

The two butterfly species, Illidge's Ant-blue butterfly (*Acrodipsas illidgei*) and the Apollo Jewel butterfly (*Hypochrysops apollo apollo*) may be particularly at risk due to their unusual life cycles as well as the more obvious predation risk. Both of these species have formed associations with native ants, in which the larvae are collected from vegetation by ants and taken to the nest where a sugary substance is excreted by the larvae and collected by the ants (Holldobler & Wilson 1990; Eastwood 1999). While the associate genus for *H. apollo*, *Iridomyrmex*, is not represented in America's fauna, the genus associated with *A. illidgei* is *Crematogaster* and in infested areas it has disappeared or suffered major declines (Wojcik *et al*. 2001). The displacement of these ant species by Red Imported Fire Ants is likely to lead to reduced recruitment of these butterflies and, therefore, place further stress on remaining populations.

### Snails

Land and freshwater snails exposed during dry conditions are also susceptible to predation by Fire Ants at all stages of their development (Stevens *et al*. 1999; Yusa 2001). Research conducted in Florida to determine the susceptibility of an endangered tree snail species, recorded a mortality rate of 86% (Forys *et al*. 2001). These results support the theory that Red Imported Fire Ants were at least partly responsible for the extinction of the Stock Island Tree snail where the ranges of these two species overlapped (Wojcik *et al*. 2001).

Two species of land snail are listed as endangered in New South Wales. They are *Meridolum corneovirens* and *Thersites mitchellae*. Of the two snail species, *M. corneovirens* is more likely to be at risk from Red Imported Fire Ants because it has a distribution restricted to open eucalypt woodlands (Rudman 2000), a habitat likely to be colonized by Red Imported Fire Ants. Although *T. mitchellae* is a rainforest species (Rudman 2000), which is a habitat unlikely to be colonized by Red Imported Fire Ants, predation may still occur due to the ability of Red Imported Fire Ants to forage up to 40 m into closed canopy forests (Forys *et al*. 2001).

### Amphibians

While only a limited number of studies and anecdotal observations have reported fire ant-induced mortality in North American amphibians (Freed & Neitman 1988; Pedersen *et al*. 1996), there are a number of species in Australia that may be vulnerable to attack because of their reproductive strategies. Of particular concern are those genera such as *Philoria* and *Pseudophyrne* that lay their eggs terrestrially, under leaf litter or in tunnels in the soil (Cogger 1994). It is likely that predation of the eggs and attending adults could occur for this group.

Amphibians with full or partial terrestrial

development are already well represented under Queensland and New South Wales' Threatened Species legislation, with the Pouched Frog (*Assa darlingtoni*), Corroboree Frog (*Pseudophryne corroboree*), a number of the Brood Frogs (*Pseudophryne pengilleyi*, *Pseudophryne australis* and *Pseudophryne covacevichae*), the Yellow belly and Masked Mountain Frogs (*Philoria kundagungan, Philoria loveridgei*) and the Spaghnum Frog (*Philoria sphagnicola*) listed. The diet of adult Red-Crowned Brood Frog (*Pseudophryne australis*) consists mainly of ants and termites (Robinson 1994) and, therefore, this species could be further impacted by simplification of ant communities.

## Turtles

The impacts of Red Imported Fire Ants on fresh and saltwater turtle species in North America have been well documented. The disturbance and mucus associated with the digging of the egg chamber and egg laying attracts Red Imported Fire Ants to nest sites. Soil movement and vibrations associated with hatching also attracts Red Imported Fire Ants (Allen *et al*. 2001) and this can lead to complete mortality of all hatchlings, with turtles killed in the egg or succumbing to the effects of the venom and dying after they emerge (Landers *et al*. 1980; Allen *et al*. 2001).

Arguably the most important Australian rookery for the Loggerhead Turtle (*Caretta caretta*) is at Mon Repos near Bundaberg in Queensland. This rookery is less than 400 km from Brisbane and is already under substantial pressure from urbanization, foxes and public use. Additional pressure from Red Imported Fire Ants could lead to greater decline in a population already dangerously low in numbers.

The Green Turtle (*Chelonia mydas*), Leathery Turtle (*Dermochelys coriacea*), Pacific Ridley (*Lepidochelys olivacea*), Bell's Turtle (*Elseya belli*), Mary River tortoise (*Elusor macrurus*), Hawksbill Turtle (*Eretmochelys imbricata*) and the Bellinger River Emydura (*Emydura macquarii*) are all conservation-listed species that could potentially be impacted by Red Imported Fire Ants.

## Terrestrial reptiles

Lizards, snakes and crocodilians (with the exception of live-bearing species) are all susceptible to predation in the nesting cavity during hatching (Moulis 1996; Allen *et al*. 1997; Chalcraft 1999). Up to 20% of alligator nests in North America contain Red Imported Fire Ant colonies and at least 50% of surviving hatchlings show evidence of attack, such as swelling of the digits and eyes and visible pustules (Allen *et al*. 1997). Attacks can also result in poor weight gain in surviving hatchlings (Allen *et al*. 1997) and this reduced weight gain of juvenile animals can result in reduced survival in the wild (Doughty 1994).

Of the crocodilians, only the Estuarine Crocodile (*Crocodylus porosus*) is listed as a Threatened Species (Vulnerable) under the Queensland Nature Conservation (Wildlife) Regulation (1994) Act. However, the number of reptiles listed as Threatened is substantial. For a full list of threatened reptiles refer to the Queensland Nature Conservation (Wildlife) Regulation (1994) and the New South Wales Threatened Species Conservation Act (1995) Schedule 1 & 2.

As well as mortality and injuries caused by attacks, decreased densities of invertebrates and simplification of ant communities may affect the population levels of native lizard species. Invertebrates make up the majority of prey species for many lizards, with most terrestrial skinks significant predators of native ants (Cogger 1994). Already, there is evidence that scincid lizards are adversely affected in Australian environments invaded by Red Imported Fire Ants (Nattrass & Vanderwoude 2001).

## Birds

Predation by Red Imported Fire Ants on the hatchlings of a number of bird species has been well documented. Species affected in North America include Egrets, Wood Ducks, Crested Caracara, Bobwhite Quails and Cliff Swallows (Drees 1992; Dickinson 1995; Killion *et al*. 1995; Mueller *et al*. 1999; Legare & Eddleman 2001). In extreme cases, entire rookeries have experienced total hatchling mortality (Drees 1992). Non-fatal attacks can also have lasting impacts upon nestlings, with chicks experiencing reduced weight gain (Allen *et al*. 1995), which may affect the likelihood of their reaching maturity (Giuliano *et al*. 1996). This is partly due to behavioural changes as a result of the presence of Red Imported Fire Ants, such as reduced feeding and resting times for young chicks (Pedersen *et al*. 1996; Mueller *et al*. 1999). Insects are an important food source for many hatchlings, therefore it would be expected that reduced invertebrate densities associated with the presence of Red Imported Fire Ants would also impact on this group (Allen *et al*. 1995).

Both terrestrial and arboreal nesting birds may potentially be impacted, because Red Imported Fire Ants will forage up to 10 m above the ground (Dickinson 1995; Forys *et al*. 2001; Legare & Eddleman 2001). However, most Red Imported Fire Ants forage on the ground surface (Forys *et al*. 2001), indicating that the greatest impacts would be on ground-nesting bird species. The following Australian species are all terrestrial nesters (Slater *et al*. 1993) and are already considered vulnerable or endangered in Eastern Australia: the Ground parrot (*Pezoporus wallicus*), the Black-breasted Button-quail (*Turnix melanogaster*), the Buff-breasted Button-quail (*Turnix olivii*), the Eastern Bristlebird (*Dasyornis brachypterus*), the Night Parrot (*Pezoporus occidentalis*), the Little Tern (*Sterna albifrons*), the Golden-shouldered Parrot (*Psephotus chrysopterygius,* the Plains Wanderer (*Pedionomus torquatus*) and the Bush Stone-curlew (*Burhinus grallarius*). Should Red Imported Fire Ants extend their range to habitats occupied by these bird species, further population declines and extinctions are likely.

## Mammals

In the USA, Red Imported Fire Ant densities and small mammal densities are negatively related (Killion *et al*. 1995). The causes of these reduced densities may be the result of direct or indirect impacts. Attacks by Red Imported Fire Ants resulting in mortality or injury, such as blinding

or the swelling of digits or limbs, have been recorded on the young of many mammal species in North America (Allen *et al*. 1997; Vinson 1997) and even where death is not immediate, these injuries may reduce the likelihood of a juvenile reaching maturity. A reduction in sight, or swollen limbs resulting from Red Imported Fire Ant stings, reduces mobility and therefore increases the probability of predation (Allen *et al*. 1997) and reduces fitness.

High Red Imported Fire Ant densities in the USA cause behavioural changes in some mammals. The Northern Pygmy Mouse (*Baiomys taylori*) avoids areas with high Red Imported Fire Ant densities when choosing potential burrow sites (Killion *et al*. 1995). When foraging in fire ant areas, Northern Pygmy Mice make significantly more trips to resource rich fragments in order to take food items to a safe location before feeding. While this behaviour is not exclusively in response to Red Imported Fire Ant presence, the Northern Pygmy Mice were three times more likely to exhibit this behaviour in fire ant areas. This behaviour is likely to increase energy costs and decrease available productive foraging time (Holtcamp *et al*. 1997), as well as increasing predation risk when the mouse is moving between the food source and suitable cover.

No particular type of terrestrial Australian mammals appear to have a life history that will result in them being more prone to negative impacts by Red Imported Fire Ants than other mammal groups. However, species that should be monitored in the event of Red Imported Fire Ants spreading beyond their current distribution are those with restricted or specialized habitats; groups such as the smaller carnivorous marsupials that rely on larger invertebrates as a food source and those that have a period when the young are unable to fend for themselves and are housed in a terrestrial den. A decline in the quantity of invertebrates caused by high Red Imported Fire Ant densities may affect carnivorous mammals, such as *Antechinus* and bandicoots, by reducing the availability of suitable prey, while juveniles may be attacked within their nest (Jourdan *et al*. 2001).

## Conclusion

As in North America, there can be little doubt that Red Imported Fire Ants will have profound impacts on Australian faunal communities if they spread beyond their current Australian distribution. The species highlighted are merely an indication of those taxa, particularly taxa already listed as Threatened, that have life histories susceptible to infestations of the Red Imported Fire Ant (although these species are unlikely to be the only ones affected if current control measures fail). While of value, the majority of available literature pertaining to the impacts of Red Imported Fire Ants on wildlife is based on studies conducted in North America, Australian fauna, however, has a high degree of endemicity and may be more or less resilient to invasion by this ant species. Therefore, it is imperative that we determine which groups have been adversely affected by Red Imported Fire Ants in its current Australian range, to establish which groups are most at risk and, therefore, where any future conservation funding would best be applied.

## Acknowledgements

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