Effect of Broadcast Baiting on Abundance Patterns of Red Imported Fire Ants (Hymenoptera: Formicidae) and Key Local Ant Genera at Long-Term Monitoring Sites in Brisbane, Australia

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ABSTRACT In 2001, the red imported fire ant (*Solenopsis invicta* Buren) was identified in Brisbane, Australia. An eradication program involving broadcast bait treatment with two insect growth regulators and a metabolic inhibitor began in September of that year and is currently ongoing. To gauge the impacts of these treatments on local ant populations, we examined long-term monitoring data and quantified abundance patterns of *S. invicta* and common local ant genera using a linear mixed-effects model. For *S. invicta*, presence in pitfalls reduced over time to zero on every site. Significantly higher numbers of *S. invicta* workers were collected on high-density polygyne sites, which took longer to disinfest compared with monogyne and low-density polygyne sites. For local ants, nine genus groups of the 10 most common genera analyzed either increased in abundance or showed no significant trend. Five of these genus groups were significantly less abundant at the start of monitoring on high-density polygyne sites compared with monogyne and low-density polygyne sites. The genus *Pheidole* significantly reduced in abundance over time, suggesting that it was affected by treatment efforts. These results demonstrate that the treatment regime used at the time successfully removed *S. invicta* from these sites in Brisbane, and that most local ant genera were not seriously impacted by the treatment. These results have important implications for current and future prophylactic treatment efforts, and suggest that native ants remain in treated areas to provide some biological resistance to *S. invicta*.

KEY WORDS *Solenopsis invicta*, red imported fire ant, ant abundance, broadcast bait, nontarget impact

Originating from central South America (Buren et al. 1974), the red imported fire ant (*Solenopsis invicta* Buren) has become a highly invasive ant species. *S. invicta*'s introduced range currently includes the southern United States (Callcott and Collins 1996), Mexico (Sanchez-Pena et al. 2005), the Caribbean (Davis et al. 2001, Wetterer and Snelling 2006), Taiwan (Chen et al. 2006, Yang et al. 2009), China (Zhang et al. 2007), and Australia (Moloney and Vanderwoude 2002). A small number of *S. invicta* colonies have been detected and successfully eradicated in New Zealand (Pascoe 2002).

Recorded impacts of *S. invicta* in the United States include impacts on invertebrates and other wildlife (reviewed in Holway et al. 2002 and Allen et al. 2004), economic losses in agricultural and urban areas (Adams 1986, Lard et al. 2002), as well as impacts on human health (e.g., Caldwell et al. 1999, deShazo 1999). Given the potential for similar impacts in Australia if it became widely established (Solley et al. 2002, Moloney and Vanderwoude 2004), *S. invicta* has been the focus of a national cost-shared eradication program in Brisbane since 2001, implemented by the Biosecurity Queensland Control Centre (BQCC) of the Queensland Department of Agriculture, Fisheries and Forestry. During the program, large areas of Brisbane have been repeatedly broadcast baited using two insect growth regulators, methoprene and pyriproxyfen, and the metabolic inhibitor hydramethylnon. Insect growth regulators affect larval development by impeding metamorphosis and sterilizing the queen (Banks et al. 1983), whereas hydramethylnon disrupts cellular respiration and causes worker death (Hollingshaus 1987).

Crucial to the success and effectiveness of broadcast bait treatments, in particular insect growth regulators, are regular and timely applications, which allow the active ingredient to circulate within the colony at a sufficient level and duration to cause colony death

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(Glancey et al. 1973, Banks 1986). Field trials with insect growth regulators and toxicants report high levels of control after several months, although with considerable variation in their maximum efficacy rates and the time taken to achieve those rates. For example, reported efficacy (percentage reduction in mound abundance) for methoprene ranged from 68 to 98% in 4 to 8 mo (see Drees and Barr 1998, Oi et al. 2004, Aubuchon et al. 2006); for pyriproxifen, efficacy ranged from 87 to 100% in 2 to 9 mo (see Banks and Lofgren 1991, Drees and Barr 1997, Barr and Best 1999, Hwang 2009); for hydramethylnon, efficacy ranged from 78 to 99% in 2 wk to 5 mo (see Apperson et al. 1984, Barr and Best 2002, Valles and Pereira 2003, Oi and Oi 2006, Hu and Song 2007). Such variation demonstrates that there are many factors that may influence treatment success, such as the amount of bait applied, weather conditions at the time of application, as well as the activity of the invasive ant species at the time of treatment (e.g., Aubuchon et al. 2006).

In addition to reducing or eliminating target ant species, repeated broadcast baiting has the potential to reduce the presence of nontarget species in the treatment area because baits are not species specific (e.g., Zakharov and Thompson 1998, Vogt et al. 2005). In the United States, there are mixed reports on the impact of repeated broadcast baiting on nontarget ants; for example, some studies have shown negative impacts for hydramethylnon (Zakharov and Thompson 1998, Vogt et al. 2005), while others have concluded no discernable impact on nontarget ants (Apperson et al. 1984, Phillips et al. 1986). As with target ant species, there are a range of factors that may influence the impact of treatments on nontarget ants including bait attractiveness, the ability to secure adequate levels of the bait, and foraging behavior.

Brisbane's subtropical climate means that the local ant fauna is relatively speciose and diverse for an urban environment, with >250 species in 69 genera collected from Brisbane bush land reserves (Burwell 2007). To date, 40 local ant genera are represented in samples from the Brisbane public over the course of the eradication program. Twelve of these genera have been observed, by BQCC staff, foraging for baits used in the program, so local ants may have been negatively impacted by the treatment efforts. Until now, no quantitative analysis of treatment impacts on nontarget ants in Brisbane has been completed.

Between 2001 and 2006, a large selection of properties infested with *S. invicta* in Brisbane was monitored by BQCC staff to assess the effectiveness of the baiting program on *S. invicta.* Monitoring involved frequent pitfall trapping, which captured both *S. invicta* and other ground-active ants present on those properties. Here, we use these data to quantitatively assess abundance trends in both *S. invicta* and local ants in response to the treatment and to examine relationships between *S. invicta* and local ant communities.

Materials and Methods

Data Collection. Between 2001 and 2006, BQCC staff established fixed monitoring sites on a range of properties in and around Brisbane. At the time, these properties were known to be infested with *S. invicta,* were readily accessible, and covered the extent of the infested area in Brisbane at the time. Monitoring sites were chosen so they included varying densities of *S. invicta* infestation on a variety of land uses including rural, semirural, industrial, and residential (Vanderwoude et al. 2004). The majority of sites were either residential properties or commercial premises, followed by roadsides, farmland, parks, and a small number of vacant, vegetated land parcels. The area surveyed for each site ranged from 150 to 4000 m^2, with an average of 532 m^2.

Each site was pitfall trapped and surveyed for *S. invicta* mounds at frequent intervals. Depending on site characteristics, between 6 and 30 pitfall traps were established in a fixed array (grid or transect) at each site, ≈4–5 m apart. Traps consisted of 18-mm-diameter rimmed laboratory test tubes set in PVC sleeves of electrical conduit. For each trapping event, traps were left open for 3 d and were filled with 4 ml of 70% ethanol with a small amount of glycerol added to reduce evaporation. When not in use, the sleeves were capped to exclude debris. Sampling occurred initially every 2 wk and subsequently at monthly intervals for the remainder of the monitoring period (between 18 mo and 4 yr). Because of logistical constraints at the time of sampling, and because *S. invicta* was the prime focus of the monitoring, nontarget ants were identified only to genus.

Each site was also surveyed multiple times throughout the monitoring period to record the location, size, and activity of *S. invicta* mounds. This information was recorded onto a map for each site. Samples of *S. invicta* workers from one or several mounds on each site were collected and later analyzed to determine whether they originated from monogyne (single queen) or polygyne (multiple queen) *S. invicta* colonies. This analysis involved isolating the presence of the *Gp-9* alleles (B and b), and classifying sites as either monogyne (BB) or polygyne (Bb; Oakey et al. 2011).

Data Collation and Analysis. For this study, we included data collected from a monitoring site if it met the following criteria: 1) sites had received the recommended minimum of four treatments per year over 3 yr, 2) sites had been pitfall trapped for at least 1 yr, 3) *S. invicta* had been collected in pitfall traps during sampling, and 4) the location of the site could be verified using aerial imagery. In total, 60 sites met these criteria. Because of the deterioration of many of the stored pitfall collections, we did not attempt further identification of ant specimens to species level.

For each site, we collated all pitfall data, calculated the initial *S. invicta* mound density from survey data, categorized land use type based on observations recorded by field staff and aerial imagery, and allocated which social form of *S. invicta* was present based on genetic analysis. Because of the large spread of den-

Table 1. Summary of the number of sites with monogyne and polygyne *S. invicta* mounds, their range of mound densities (low density, <500 mounds per hectare; high density, >500 mounds per hectare), and the average total monitoring periods including the average length of time that *S. invicta* was recorded as present and absent from pitfalls at each site type

Site data	Low density		High density polygyne	All sites total
	Monogyne	Polygyne		
No. sites with each form of *S. invicta*	22	23	15	60
Mound density range (mounds per hectare)	22–483	44–495	531–5059	22–5059
Mean total monitoring period (mo)	33.2	36.6	39.8	36.2
Mean period with *S. invicta* (mo)	9.7	11.1	13.9	11.4
Mean period after *S. invicta* (mo)	23.5	25.5	25.9	24.8

sities for sites with polygyne *S. invicta* mounds, we decided to split these sites into low (<500 mounds per hectare)- and high (>500 mounds per hectare)-density polygyne sites for analysis.

When collating the pitfall data, we made the following decisions in terms of taxonomic groupings. First, we pooled counts of ants that were identified as either *Tapinoma* or *Technomyrmex* because of the difficult taxonomic feature that separates these ants (a single tergite on the gaster that can be retracted and difficult to see; Shattuck 1999). Second, we retained the classification of "*Paratrechina*" for ants from the genera *Paratrechina, Nylanderia,* and *Paraparatrechina,* as this was the name in use at the time these ants were sorted (*Paratrechina* has recently been classed as a monotypic genus including only the introduced *Paratrechina longicornis* (Latreille, 1802); LaPolla et al. 2010).

To examine any changes in ant abundance over time, a linear mixed-effects model (Sorensen and Gianola 2002) was developed. For changes in *S. invicta* abundance over time, the model was represented by:

$$\text{Counts of } S.\ invicta = \text{Intercept} + \text{Day} + \text{Day}^2 + \text{Day}^3 + \text{Form} + Site + Site \times Day + \varepsilon$$

where Intercept represents the number of *S. invicta* workers collected at day 0 (the first day of trapping), Day represents the total number of *S. invicta* workers trapped for each trapping event, and Form compares the number of *S. invicta* workers trapped at day 0 between sites with either monogyne, low-density polygyne, and high-density polygyne *S. invicta* colonies. Site and Site × Day were fitted as random effects, and ϵ represents the random error.

For changes in the abundance of nontarget ant genera over time, the model was represented by:

$$\text{Counts of (genus)} = \text{Intercept} + \text{Day} + \text{Form} + \text{Form} \times \text{Day} + \log\,(S.\ invicta\ +\ 1) + site + \varepsilon$$

where Intercept represents the number of ants for each genus collected at day 0 (the first day of trapping), Day represents the total number of ants for each genus trapped for each trapping event, and Form compares the number of ants for each genus trapped at day 0 between sites with either monogyne, low-density polygyne, or high-density polygyne *S. invicta* colonies. Site was fitted as a random effect, and ϵ represents the random error. To allow us to detect meaningful trends within the data, we only included ant genera in the analysis that were collected from 10 or more sites, and represented by >10 individuals in traps from those sites. This meant that only 10 genus groups were included in this analysis, namely, *Iridomyrmex, "Paratrechina," Rhytidoponera, Cardiocondyla, Ochetellus, Polyrhachis, Tapinoma/Technomyrmex, Pheidole, Tetramorium,* and *Notoncus.*

As we were only interested in identifying trends in the abundance of local ant genera, and not using this model for predictive purposes, we chose to present the results in interpretive form. For each variable, the 95% confidence intervals were examined for each coefficient and deemed as either significant or not significant (at the 5% level). Each significant result is presented in Table 2 as a statement of the trend observed in the analysis (e.g., if the confidence intervals for Day were positive, then we use the statement "abundance increased over time"). Results that were not significant are listed as such.

For both models, we tested trap array and land use as fixed effects, as well as trap within site as a random effect, but none of these were found to significantly contribute to the variation in the data and were excluded from the final models. Intercept results are not reported as *S. invicta,* and each local ant genera analyzed recorded significantly positive counts at the start of monitoring.

Data were log+1 transformed before analysis to normalize their distribution. Parameters were estimated using a Bayesian analysis, with prior distributions for the unknown parameters taken to be vague conjugate priors, i.e., Normal and Wishart distributions. The Gibbs sampler was run for 55,000 iterations, with a burn-in of 5,000 iterations and a thinning of 100. Thinning was used to reduce the autocorrelation in the Markov chain Monte Carlo (MCMC) chains, which were used to estimate the parameters. The models were fitted using the package MCMCglmm (Hadfield 2010) in the R statistical software package (R Development Core Team 2012).

Results

Presence of *S. invicta*. Overall, sites were monitored for an average of 3 yr, with *S. invicta* present in pitfalls for an average of 11 mo (Table 1). Monogyne *S. invicta* colonies were recorded on 22 sites, and did not exceed mound densities of >500 mounds per hectare (Table 1).

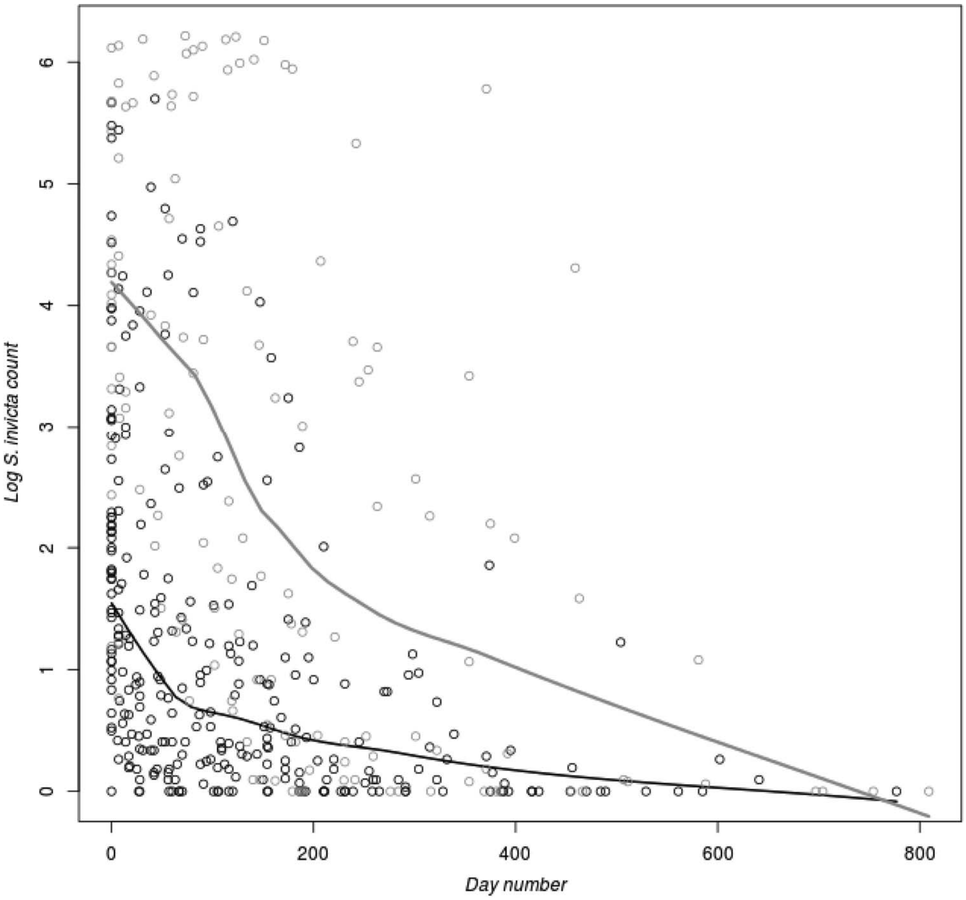


Fig. 1. Plot of *S. invicta* abundance in pitfall traps over time. Points represent the log (mean *S. invicta* counts) at the site level. Lines represent a spline fit. Gray points and line indicate high-density polygyne sites; black points and line indicate both monogyne and low-density polygyne sites (low density, <500 mounds per hectare; high density, >500 mounds per hectare).

Polygyne *S. invicta* colonies were recorded on 38 sites, and displayed a much wider range of mound densities compared with monogyne sites (Table 1), with five sites having >1,000 mounds per hectare.

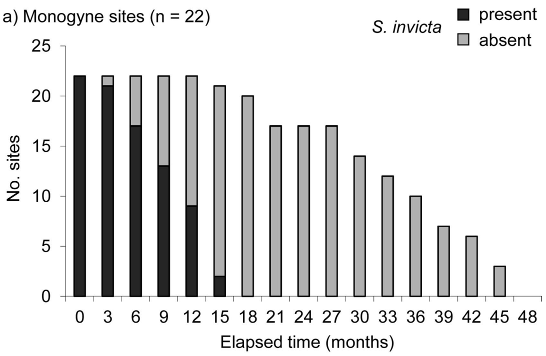
Regardless of *S. invicta*'s initial mound density on a site, the abundance of *S. invicta* in traps significantly decreased over time (Day = −1.6E3, [−1.71E3, −1.62E3], Fig. 1). Sites with high-density polygyne *S. invicta* mounds had significantly higher numbers of *S. invicta* in traps (Form = 0.89, [0.54, 1.23]) compared with sites with monogyne or low-density polygyne mounds (Fig. 1). As such, high-density polygyne sites took longer to disinfest than monogyne or low-density polygyne sites (Fig. 2). There was no significant difference in abundance between sites with monogyne and low-density polygyne mounds (Form = 0.16 [−0.15, 0.47]). Once *S. invicta* had reduced to zero on a site, it was not collected in traps for the remainder of the monitoring period, which equated to an average of almost 25 mo (Table 1).

Presence of Nontarget Ant Genera. In total, 36 nontarget ant genera from eight subfamilies were collected in pitfall traps during monitoring (Table 3). In addition to *S. invicta*, three local ant genera—*Iridomyrmex*, *"Paratrechina,"* and *Rhytidoponera*—were collected at all 60 sites (Table 3).

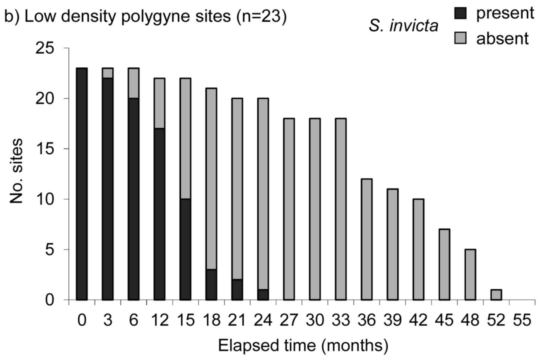
At the start of monitoring, significantly fewer specimens of *Iridomyrmex, Cardiocondyla, Tapinoma/Technomyrmex*, and *Notoncus* were collected in traps on sites with high-density polygyne mounds, compared with sites with monogyne or low-density polygyne mounds (Table 2). In addition, significantly fewer *Rhytidoponera* were collected in traps on sites with low- and high-density polygyne mounds compared with sites with monogyne mounds (Table 2).

Iridomyrmex, "Paratrechina," Ochetellus, Polyrhachis, and *Notoncus* all significantly increased in abundance over time while there was no significant change in the abundance of *Rhytidoponera, Cardiocondyla, Tapinoma/Technomyrmex*, and *Tetramorium* (Table 2). *Iridomyrmex* was the only genus to show a significant, rapid increase in its numbers once *S. invicta* had reduced to zero (Table 2). A single ant genus (*Pheidole*) significantly decreased its abundance over time,

a) Monogyne sites (n = 22)



b) Low density polygyne sites (n=23)



c) High density polygyne sites (n=15)

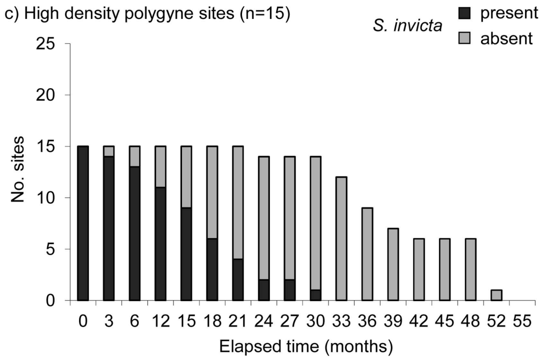


Fig. 2. Number of active monitoring sites and the number of sites infested with (a) monogyne, (b) low-density polygyne, and (c) high-density polygyne *S. invicta* colonies at three monthly intervals until monitoring ceased (low density, <500 mounds per hectare; high density, >500 mounds per hectare).

recording the same pattern shown by *S. invicta* (Table 2). The abundance of *Pheidole* showed no significant trends in relation to *S. invicta*'s abundance or form.

Discussion

At the time of this study, the standard treatment regime for *S. invicta* in Brisbane was a minimum of four treatments per year over 3 yr with two insect growth regulators (pyriproxifen or methoprene) and a toxicant (hydramethylnon). Choice of bait and sequencing were influenced by site type and conditions. Baits were applied by hand-held spreaders or dispersed mechanically from hoppers mounted on all-terrain vehicles or helicopters. The results reported here for 60 infested sites around Brisbane between 2001 and 2006 demonstrate that this treatment regime removed *S. invicta* from the sites examined in this analysis. This was the case regardless of the form of *S. invicta* (monogyne or polygyne), its initial mound density, or the land use type of the sites. Of the 60 sites examined, seven sites have become reinfested with *S. invicta:* five sites recorded new mounds after 10 yr, one site after 7 yr, and one site after 4 yr, indicating that these new mounds were reinvasions rather than survivals from treatment.

Sites with high-density polygyne *S. invicta* mounds took longer to disinfest compared with sites with monogyne or low-density polygyne mounds. There may be several reasons for this. At any efficacy rate below 100%, mathematically, it would take more rounds of treatment for survivorship to drop below one mound per hectare on higher density sites than for lower density sites. For insect growth regulators to work effectively, the active chemical must be maintained within the colony at levels high enough to cause brood production to cease and for periods long enough to allow the colony to age and die (Bigley and Vinson 1979, Banks et al. 1983). At high initial populations of *S. invicta,* competition between colonies for available bait may result in insufficient quantities of chemical circulating within some colonies, allowing them to persist for longer compared with populations with lower densities. In addition, a polygyne colony with multiple queens may take longer to kill than a monogyne colony with a single queen depending on the amount of chemical circulating in the colony.

Of the 10 local ant genera included in our analysis, only *Pheidole* significantly declined in abundance over time. This decline was similar to that recorded for *S. invicta,* suggesting that *Pheidole* was impacted by treatment efforts on these sites. Hydramethylnon is registered for use against the invasive ant *Pheidole megacephala,* which is common in urban Brisbane (Burwell 2007). Hydramethylnon has been used to successfully control infestations of *P. megacephala* elsewhere (Reimer and Beardsley 1990, Warner et al. 2008, Gaigher et al. 2012), so it is not surprising that it may impact at the broader generic level, as suggested by our results. Unfortunately, we do not know how many or which *Pheidole* species comprised our pitfall catches. However, unlike the situation for *S. invicta, Pheidole* reappeared in traps on 24% of sites by the end of the monitoring period, indicating some recovery by this genus posttreatment.

The remaining commonly observed genera either increased in abundance over time or showed no significant increase or decrease. At least at the generic level, these ants did not appear to be affected by the treatment regime. This was surprising, given the long-term and large-scale nature of the treatment regime, and the fact that ants from most of the genera we analyzed—with the exception of *Tetramorium* and *Tapinoma*/*Technomyrmex*—have been observed, by BQCC staff, visiting bait stations and removing bait

Table 2. Summary and interpretation of model output for the most common ant genera collected on monitoring sites

Model variable	Model results		
	Form (*S. invicta*)	Day	Count (*S. invicta*)
Interpretation of model output	Was abundance different on day 0 between sites with M or P mounds?	Did trends in abundance change over time?	Did trends in local ant abundance change once *S. invicta* became absent?
Iridomyrmex	Lower on HDP sites	Increased	Increased more rapidly
"*Paratrechina*"	n/s	Increased	n/s
Rhytidoponera	Lower on P sites	n/s	n/s
Cardiocondyla	Lower on HDP sites	n/s	n/s
Ochetellus	n/s	Increased	n/s
Polyrhachis	n/s	Increased	n/s
Tapinoma/Technomyrmex	Lower on HDP sites	n/s	n/s
Pheidole	n/s	Decreased	n/s
Tetramorium	n/s	n/s	n/s
Notoncus	Lower on HDP sites	Increased	n/s

Significant results ($P < 0.05$) are listed as a statement, and nonsignificant results are listed as n/s. Form compared abundance at the start of monitoring between monogyne (M), low-density (LD) polygyne (P), and high-density (HD) polygyne (P) sites. Day refers to the abundance in traps over time. Count refers to abundance of each local ant group compared with counts of *S. invicta* in traps over time.

during trials. The lack of treatment impacts could be explained by native ants securing insufficient amounts of the bait in treated areas and therefore not being affected by it. Alternatively, for at least some genera, colonies may have survived in situ because of their colony organization. For example, most species of *Rhytidoponera* lack queens and instead have fertilized workers (gamergates) which produce brood. In some species, where true queens are present, the queens may be replaced by fertilized workers when they die (Ward 1986). This reproductive strategy may help *Rhytidoponera* survive catastrophic events (Chapuisat and Crozier 2001).

In the absence of species-level data, it is possible that some individual species were impacted, but this was not detected in our analysis because the trend was not expressed at the generic level. We cannot, therefore, conclude that no local ants other than *Pheidole* were affected by the treatment. However, the fact that nine out of the 10 most common genera analyzed either maintained their presence on treated sites or significantly increased their numbers while treatment was occurring, is encouraging. Limited data available on individual species in pitfalls show that at least some of the key competitors of *S. invicta,* such as species in the *Iridomyrmex rufoniger* and *Rhytidoponera metallica* groups, were among those still present at the end of the monitoring period (M.K.M. and F.R.W., unpublished data).

The constraints of working within an eradication program mean that we have no baseline data about the ant communities present on the 60 study sites either before the arrival of *S. invicta* or before the baiting program commenced. As it was impossible to secure untreated infested sites for use as controls because of the imperative to treat all known *S. invicta* colonies, our examination of the impacts of *S. invicta* and the bait treatments on the local ant fauna is restricted to what occurred on the monitoring sites after *S. invicta* was established. However, some information on the local ants that may have been present is available from a study conducted by van Gils (2002), which compared the ant fauna on 10 parkland and industrial sites in urban Brisbane in Autumn or Winter of 2002 using the same sampling methodology. These sites were not infested by *S. invicta* and were untreated. All 23 genera collected by van Gils (2002) are included among the 36 genera collected in our study (listed in Table 3), and the most common genera are the same for both studies. Additional information on the ant fauna typical to sites such as ours comes from surveys of suburban gardens in Brisbane (C.J.B., unpublished data) where 34 ant genera were common or occurring in modified urban landscapes, 28 of which were recorded in our pitfalls. Thus, at least at the generic level, ant assemblages recorded at our sites appear representative of what would have been present before the arrival of *S. invicta* and the start of treatment.

In this study, when *S. invicta* mound densities were low (on monogyne and low-density polygyne sites), it appeared that local ant abundance was not significantly impacted by the presence of *S. invicta.* However, when mound densities were high (on high-density polygyne sites), some genera recorded significantly lower abundances at the start of monitoring, reflecting the very high mound densities on some sites that created a "blanket" of *S. invicta* mounds. To illustrate, the high-density polygyne sites in Brisbane averaged 1,185 mounds per hectare, undoubtedly impacting the ability of native ants to establish or persist there. The ecological impacts of monogyne and polygyne populations of *S. invicta* are very different and are likely to be more severe for polygyne populations (e.g., Porter and Savignano 1990, but see Morrison 2002). The results of our Brisbane study support that contention; however, the most common native ants recorded in traps were present on all monitoring sites, including the sites that recorded extremely high *S. invicta* densities.

Because *S. invicta* often establishes in areas of disturbed land (e.g., Tschinkel 1988, Stiles and Jones 1998, Zhang et al. 2007), it can be difficult to ascertain

Table 3. List of ant genera and the number of sites from which they were collected in this study, along with their presence (✓) or absence (✗) from two additional studies conducted in urban Brisbane

Ant genus	This study	Other studies in urban Brisbane	
	No. sites collected	(van Gils 2002)	(C.J.B., unpublished data)
Dolichoderinae			
Iridomyrmex	60	✓	✓
Ochetellus	45	✓	✓
Tapinoma/Technomyrmex	42	✓	✓
Dolichoderus	1	✗	✗
Formicinae			
"Paratrechina"	60	✓	✓
Polyrhachis	44	✓	✓
Notoncus	32	✓	✓
Stigmacros	27	✓	✓
Camponotus	25	✓	✓
Melophorus	16	✓	✗
Opisthopsis	11	✓	✓
Plagiolepis	7	✓	✓
Calomyrmex	2	✗	✗
Acropyga	1	✗	✗
Ectatomminae			
Rhytidoponera	60	✓	✓
Ponerinae			
Hypoponera	25	✗	✓
Pachycondyla	12	✓	✓
Anochetus	10	✗	✓
Ponera	5	✗	✗
Heteroponerinae			
Heteroponera	1	✗	✗
Myrmicinae			
Cardiocondyla	52	✓	✓
Pheidole	37	✓	✓
Tetramorium	37	✓	✓
Solenopsis	35	✓	✓
Monomorium	25	✓	✓
Strumigenys	23	✗	✓
Carebara	11	✗	✓
Crematogaster	10	✗	✓
Aphaenogaster	7	✗	✓
Colobostruma	7	✓	✓
Epopostruma	6	✓	✗
Meranoplus	6	✓	✓
Cerapachyinae			
Cerapachys	22	✓	✓
Sphinctomyrmex	1	✗	✗
Aenictinae			
Aenictus	2	✗	✗

"Paratrechina" may include the genera *Paratrechina*, *Nylanderia*, and *Paraparatrechina*.

the impacts of its presence, as distinct from the impact of habitat disturbance, on local ant assemblages (see King and Tschinkel 2006). As with the experience in the United States, most occurrences of *S. invicta* in south-east Queensland have been associated with habitat disturbance. Over the past 4 yr, ≈70% of all new detections for monogyne *S. invicta* colonies in this region have been linked to significant soil disturbance (F.R.W., unpublished data). Despite this, Brisbane's urban habitats do not necessarily have a depauperate fauna of local ants (Burwell 2007). For example, overall abundance of ants and the number of ant species sampled by pitfall traps in suburban gardens compared with eucalypt forest reserves within the urban matrix are not significantly different (C.J.B., unpublished data). Suburban gardens, however, do have very different assemblages of ant species compared with forests, and include numerous species—both native and introduced—that favor open, disturbed habitats.

In Brisbane, the most abundant ant genera in this study—*Iridomyrmex*, *"Paratrechina,"* and *Rhytidoponera*—are common in urban landscapes, and are composed of native species (apart from *P. longicornis*) that can largely be considered "hardy" disturbance specialists. Hoffmann and Andersen (2003) recognize *R. metallica* group and some *Iridomyrmex* species as "increasers" in response to disturbance. Dolichoderines, particularly in the genus *Iridomyrmex*, are well known for their aggressive behavior and almost always dominate native ant communities in open habitats (Lach and Thomas 2008), and this group has been hypothesized to limit the range expansion of many invasive ants (Andersen 1997). In our study, *Iridomyrmex* recorded a rapid increase in abundance after *S. invicta* was reduced to zero, which matches observations made throughout the program of *I. rufoniger* frequently sharing mounds with *S. invicta* and occupying old and abandoned *S. invicta* mounds posttreatment.

In addition, *R. metallica* workers have been observed attacking *S. invicta* workers in the field (M.K.M., unpublished data).

Thus, this study indicates that south-east Queensland has its own disturbed habitat specialists that were able to persist on these sites despite the presence of *S. invicta,* and appeared to be largely unaffected by the baiting program used against *S. invicta* at the time. This suggests that there are local ants remaining that are capable of providing some biological resistance to *S. invicta*—an important consideration for current and future prophylactic treatments with broadcast baits.

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